GENERAL SCIENCE QUARTERLY

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Published four times a year: in November, January, March and May
By W. G. WHITMAN, SALEM, MASS.
Entered as second class matter Nov. 6, 1916, at Salem, Mass., under the Act of March 3, 1879

$1.50 a year
40c a copy

JANUARY, 1925

VOLUME 9
NUMBER 2

General Science Quarterly

Vol. IX JANUARY 1925 No. 2

Devices and Methods in Natural Science*

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"The value of any study depends on how the teacher teaches it and what the pupil learns from it."

"Doubling one's power to get and to use knowledge is doubtless worth far more than doubling one's knowledge."—*Thorndike.*

INTRODUCTION.

The following outline of certain methods employed in Junior High School science teaching is based upon experience in the Latimer Junior High School of Pittsburgh, Pennsylvania.

Discussion and criticism of methods of instruction now in use, and the pooling of all that proves to be successful in the experience of many teachers, is the way to improvement in the teaching of science in our Junior High School.

Science teachers who are interested should send criticisms, suggestions and constructive ideas that will help make this Junior High School program better than any one person can make.

The intermediate grades, 7 to 9 inclusive, or those comprising the Junior High School, constitute preeminently an exploratory period, a trying-out period to which the Heuristic method of science is particularly adapted. The content of the science work of this period is not a delicately balanced conglomerate of physics, biology, chemistry, and physical geography, but a course based upon the social, hygienic, and economic needs and interests of pupils of the early adolescent age. The progressive and normal development of a pupil, for example as an increasingly worthy member of his home, needs to be traced and outlined, step by step, and the other subjects brought to bear upon a solution of the problems involved. This is the period when amateur scientists are developed. Witness widespread interest among boys and girls of this age in the recent extensions of the use of the wire-

*This is an outline of a paper given at the N. E. A. in Washington, D. C., July 1, 1924 and at Pennsylvania State Ed. Assn. meeting at Erie, Dec. 21, 1924.

less and the automobile. The science club both curricular and extra-curricular with its opportunity to develop and play with scientific hobbies and toys is admirably adapted to this period and should be encouraged. From being largely empirical, the thinking of the pupil rapidly becomes more constructive and under the skilful guidance of the teacher will enable him successfully to work his way through problems of considerable complexity.

In general, the course will stress the science of home and community life, with special reference to those features that make the pupil more socially efficient on the playground, at home, at school, and in a community. A rigid syllabus for the science work of this period applicable to all schools alike is unthinkable. Rich in its suggestions of materials and methods, the syllabus must leave each teacher free to work out his own course in terms of the special needs and interests of the varying groups of girls and boys in his classes. There is no substitute for a skilful and resourceful teacher of science in these intermediate grades. A prominent educator has recently said, "My observation leads me to say that the position of teacher of science in this all-important period is the key position, no other subject excepted, in the whole high school range, from the seventh grade to the twelfth, and should attract, as indeed it requires, the most skilful and the most human of teachers."

The course in science should be continuous throughout this period. The time allotment should be approximately the equivalent of two years of work in a single subject four hours per week. Probably the best distribution of this time would give two hours per week throughout the seventh and eighth grades and four hours per week during the ninth grade.

It goes almost without saying that the Junior High School science course, if it is to realize its full values, cannot well be a text-book course. Materials of instruction must be chosen with reference to the needs and resources of the local community on the one hand and the interests and capacities of each class group of pupils on the other. *Several* texts can well be used and these as reference books rather than as texts out of which consecutive lessons are assigned. Such a course must never be allowed to become fixed or static for a city or a school or even an individual teacher. New materials and new methods must be constantly sought and adapted to meet the need of varying groups of pupils

and, so far as possible, to meet in some measure the special interest of individual pupils.

It goes without saying, also, that the *problem project* method of instruction is the one best adapted to this exploratory period, so that young people may have the opportunity to express themselves individually along lines of their fundamental instincts and interests and thus develop lines of individual aptitudes. This is not to say that the problem project method should be used exclusively. The work will necessarily have to be developed by use of:

1. Clubs
2. Visualization work
3. Note books
4. Recitation and demonstration
5. Reference material
6. Correlation

I. THE SCIENCE CLUB

It is said, "Self activity is the law of growth." The aim of the club is to encourage general scientific knowledge; to have every child function; to help the teacher get better interest; to encourage the pupil to present the thing he is most interested in; to help him do better the thing he will do any way; the child's interest is often formed in him and is given an enthusiasm started by his classmates rather than by the teacher. It developes leadership; teaches self-reliance and the appreciation of the important part that science plays in the every-day life of every citizen.

The time should be one class period per week.

The officers are as follows:

1. President
2. Vice-President
3. Secretary-Treasurer
4. Sergeant-at-Arms
5. Club Editor and English Critic
6. Magazine Buyer
7. Note Book Critic

The duties of the President are: to take charge of the club meetings; to see that those having topics are prepared; to take charge of room when teacher is out; puts "pep" into the club; invites criticism; visits other clubs; post club standing each week; arranges for visits to factories, etc.

The Vice-President marks each pupil for work done in club according to a scale agreed upon by the club and teacher. All the officers receive A or B. Any officers who cannot earn such a mark is promptly removed from office. The club marks of the class are submitted to the teacher at the end of the month for his or her approval.

The Secretary-Treasurer keeps the minutes of all meetings; marks short topics which are held over; keeps time of illustrated topics; appoints timekeeper; assigns topics.

The Sergeant-at-Arms sees that magazines are kept in order; operates lantern; attends to shades; appoints a light regulator; keeps the club room in order.

The Club Editor places all important news in the school paper, LATIMER LIFE; also criticizes the English of all topics.

The Magazine Buyer purchases all the latest magazines on science as soon as they are on the market.

2. VISUALIZATION DAY

This type of recitation is in the experimental stage. The aim is to try to turn the Motion and Still Pictures from entertainment to educational purposes. They are shown one day each week. Only pictures based on the project at hand are shown. Notes and drawings are made as the picture is shown. About half the period is taken for the showing and the other half for the writing up the subject.

3. NOTE BOOK WORK

"Improvement of laboratory practice will result in less cumbersome forms of note-taking and of note-book making. The experiment is not designed for the sake of a note-book record. A summary of results which can be used in interpreting the work done should be done and pupils should be allowed such freedom in the precise manner in which the record is made. They should record important and significant facts, and the record should be clear and complete."

4. RECITATION AND DEMONSTRATION

The problem project method is the best suited for this age of pupils. The problem and projects are unified on the basis of individual experiments, class discussion, reference and laboratory work by individuals and small groups. "Too frequently the laboratory and class room are separate not only physically but mentally." "The value of individual laboratory work has been seriously injured by requiring each pupil to do exactly the same experiment as every other pupil and to do it in as nearly the same time and the same way as possible." The class room should be made a workshop. Each child has a right to work out the thing he or she desires. Co-operation in a group project frequently has high social values.

The basis of the course is:

1. "Cardinal Principles of Secondary Education," Bulletin 1918, No. 35, Department of Interior Bureau of Education.

2. "Reorganization of Science in Secondary Schools," Bulletin 1920, No. 26, Department of Interior Bureau of Education.

3. Junior High School Science Course, February, 1923, Pennsylvania State Department of Public Instruction.

Seventh Grade—Continuation of nature study.
Astronomical and physical geography.
Eighth Grade—Health. Scientific knowledge as basis.
Ninth Grade—

1st Semester	*2nd Semester*
1. Home planning	1. Communication—Radio
2. Home heating	2. Transportation—Automobile
3. Home lighting	3. Man's place in the animal kingdom
4. Pittsburgh water supply	

5. REFERENCE MATERIAL
   - I. Science books for school library.
   - II. Reference books for class use.

6. CORRELATION
   - I. English Department
     - (1) Use motion pictures and projects for basis of compositions.
   - II. Sewing Department
     - (a) (1) Boys in science class learn to sew on buttons tailor fashion.
       - (2) Mend tears.
       - (3) Press clothing. Spot removing.
       - (4) Darning.
     - (b) Six lessons for the sewing department girls to be given in science.
       - (1) Science of the home.
         - a. Clothing and its care.
         - b. Construction of a sewing machine.
         - c. Testing gas flames for heating qualities.
         - d. Home planning.
       - (2) Health
         - a. Testing the senses.
         - b. How life begins.

III. Social Studies. Knowledge of how to co-operate effectively as in questions of public health and public service generally.

IV. Health
Scientific knowledge is basic.

NEW LISTS BEING PREPARED FOR THIS COURSE

1. Science books suggested for school library.
2. Reference books for class use.
3. Laboratory equipment in this course.
4. General science texts for correlation.
5. Motion picture reels for class use.
6. Tests of motion picture reels for class use.

Factors Influencing the Teaching of Nature Study and other Elementary Sciences

CHRISTINE HARTLEY, Austin High School, Chicago, Ill.

CURIOSITY as to why so many elementary teachers dislike to teach Nature Study and Elementary Science has led to this investigation.

The conclusions are based on what the teachers themselves say, what experts in this line say, the work in science required in seventy-seven Normal Schools chosen at random, outlines of science courses for elementary schools, and state and city programs.

I. Until recently there has been much difference of opinion as to the real purpose of teaching Nature Study and other elementary sciences. By actual count, nineteen different objectives were found in the articles examined. These articles were written by experts in this line. The objectives varied purely from sentimental aims to those of teaching purely scientific facts. However, judging by the frequency of these ideas, the predominant ones are "to obtain knowledge of and interest in the world about us;" "to cultivate the habit of observing and interpreting what is seen;" "to regulate human conduct by understanding nature;" "a source of happiness throughout life, for they are used as a basis for understanding art, the world's best literature, geography, etc.;" "to help one to better enjoy leisure time;" "to acquire facts" and to "love nature."

II. Too often administrators and teachers lack sufficient training in these subjects. It is possible for pupils to get through 14.9 per cent of the high schools in the United States with no science training; 9.2 per cent require one-half year; 58.5 per cent specify

one year. So, of those schools that require science, 67.7 per cent require one year or less.[1]

Then on examining the course of study for seventy-seven normal schools, which are probably a fair sample for they were chosen at random and represent all sections of the United States, it is found that it is still possible to graduate from some of them without being required to study science. Where just one science is required, it is usually a course in geography and everyone has studied that at some time in school.

Of those that do require definite courses, many are just twelve weeks in length, so "the range is very limited."

DATA CONCERNING SEVENTY-SEVEN NORMAL SCHOOLS

No. of science courses required	No. of schools requiring these in each department Pre-normal	Primary	Intermediate	Upper grades	Junior H. S.	Rural	General	Total
1..........	0	1	0	1	1	1	0	4
2..........	1	13	6	2	2	1	13	38
3..........	4	20	15	2	5	4	9	59
4..........	3	2	7	0	4	3	8	27
5..........	5	1	2	1	5	9	1	24
6..........	2	1			1	1	2	7
7..........							1	1
8..........	2							2
No. of the 77 normals requiring courses in various departments	17	38	30	6	18	19	34	

Pre-normal courses are for students who have only completed the eighth grade.

"Most common subjects required in normal schools have been required in high school, so the student is better prepared to teach these subjects than she would be to teach nature study, even though she chose to take nature study at normal."

"The lack of knowledge of normal students regarding the most elementary of nature's forms is astonishing. One normal school instructor found that the average high school pupil coming into his classes knows about eight trees, eight birds, and eight insects. With the meagre training given in normal schools, teachers are expected to go out and teach nature study."[2]

1 Data from reports of U. S. Commissioner of Education. E. R. Downing—"School Science and Mathematics," Jan., 1924.

2 Ora May Carrol—Nature Study Magazine, 1914.

"Nobody can teach what he doesn't know. The bane of many schools is that those who assume to teach don't know enough. Many normal schools are keenly conscious of the fact and devote so much of their limited time to reviews of academic work that they have no preparation proper. The bona fide graduates of a reputable secondary school ought to know enough to teach in an elementary grade. But some normal schools accept secondary graduates, whose principals never would venture to grant a college entrance certificate and in turn pass these into the teaching profession. A further difficulty is that often thoroughly good high school graduates have never studied at all the sciences and history and literature so necessary to the young person who is destined to meet the inquisitive minds of the children of elementary grades."[3]

In the various normal schools, courses are required in Geography, Physical Geography, Professional Geography, Political Geography, Human Geography, Principles in Geography, Problems in Geography and Methods in Geography. How can any of these be taught without overlapping some of the others and thus wasting time? Why not, instead of offering so many divisions of the subject, group them and offer one good course in Geography? Let methods be a part of rather than separated from the course.

Normal schools, alone, are not responsible for poor science teaching. Records show that many college trained teachers, who have majored in science, have chosen every conceivable kind of a subject for a minor. Even if the college and normal training were adequate for their students, it must not be forgotten that we have in our public schools 30,000 with no education beyond the eighth grade; 100,000 who have had less than two years beyond the eighth grade; 200,000 who have had less than four years beyond the eighth grade; and 300,000 who have had no more than four years beyond the eighth grade. Fully 30,000 negro teachers have no education beyond the sixth grade.[4]

Sixty-three per cent of all the teachers in Alabama have had no professional training; 6,000 teachers in rural Texas have just completed the seventh grade; in Mississippi, Georgia, South Caroline and Florida 20% of the teachers have never gone beyond the eighth grade; 39% of the rural teachers in Pennsylvania had no

3 H. C. Morrison—Elementary School Journal, 1920.

4 N. E. A. Bulletin 3, 1918.

secondary training and, of the 61% who had attended high school, only 22% had completed a four-year course; 52% of the teachers held provisional certificates during the year 1919-20.[5]

III. In various syllabi, well organized and useful courses are suggested. These are particularly good for teachers who are not well trained for the teaching of these subjects, as the topics are classified according to the age of the child and the seasons. The best ones can be used as a pattern and adapted to the needs and interests of any community. "Definite standards as for history cannot be established. Nature study should and always will retain a certain flexibility."[6] These courses give much room for the initiative of the pupils and the teachers. "Although the topics vary according to locality the underlying principles are the same."[7]

"Some outlines give too much prominence to the information side. Such courses cause teachers to turn to books instead of putting questions to nature; thus the whole subject degenerates into a memorized jumble of names and an acquisition of disorganized and often useless facts."[8]

IV. The amount of time allotted to these subjects, in various elementary schools where they are taught, ranges from no time to 300 minutes per week. Mr. Trafton says that "in New Jersey about 30 minutes a week is allotted to Nature Study and occasionally 45 to 60 minutes."[9] Miss Bilig found that in seventy-one schools in Kansas the time varied from no regular periods to 5 hours per week; the average was 68 minutes per week in 1918.[10] In Illinois she found that 15 to 100 minutes per week, the average being 50 minutes broken up into two to five recitation periods, were given to Nature Study.[11] In Colorado 20 to 30 minutes per week are given to Nature Study and Hygiene; in Massachusetts 60 minutes; in Seattle 20 to 40 minutes, and in Birmingham, Ala., 50 to 150 minutes.

V. The answers received from questionnaires sent out to the teachers of these subjects in Passaic, N. J., probably express the rather general attitude of teachers towards these subjects. These teachers represent twenty-one normal schools in six different states.

5 The Rural Teacher Situation in the United States. Mabel Carney, May, 1923.

6 F. H. Holtz—Nature Study Review, 1917.

7 G. H. Trafton—Nature Study Review, 1916.

8 T. R. Croswell—Nature Study Review, 1906.

9 G. H. Trafton—Nature Study Review, 1910.

10 Florence Bilig—Nature Study Review, 1918.

11 Florence Bilig—Nature Study Review, 1915.

They have difficulty in gathering material; lack knowledge of the subject matter; lack time for presenting the work. They feel they should have had more training in observation more field work and more model lessons while in normal school.[12]

VI. It seems that those who dislike to teach these subjects are not sufficiently trained in subject matter or in methods of making it a part of the child's experience. Because of this lack, they are unable to find sufficient materials to present and to evaluate those they do find.

If they knew these subjects well, they might readily correlate their science teaching with the various other subjects and not feel the lack of time so keenly. As S. C. Schmuker says, "It should be a drawing lesson one day, a language lesson another, a geography lesson the third, the number lesson still another day, a special feature some morning at opening exercises or a stirring round-up to keep the week's work from 'petering out' on Friday afternoon."[13]

"The selection of materials and the method must be worked out by the individual teachers in their local environment. What is fit for garbage in the hands of one teacher may be invaluable as treated by another from another point of view. It is the teacher who is responsible for the use of her own and her pupils' time."[14]

"If each normal school student should find her own specimen, bring in food plants, make the vivarium or aquarium, stock it, keep it in order, study the possibilities and difficulties connected with it, the possible causes of failure and the best ways to prevent or remedy them, then, make their own garden, then they could direct their own pupils when they become teachers and save much wasted time."[15]

Dr. Broadhurst says, "No teacher has the right to teach children for two hundred days a year without having taken courses in physiology, hygiene, and bacteriology.

"It is an error to believe good teaching is uniformly possible with the limited training and experience of the average grade teacher. The training of the teacher is the fundamental element upon which the foundation of Nature Study rests."[16] This statement might well include the other elementary sciences, too.

12 G. H. Trafton—Nature Study Review, 1907.
13 S. C. Schmucker—Nature Study Review, 1917.
14 E. B. Babcock—Nature Study Review, 1912.
15 Laethitia M. Snow—Nature Study Review, 1910.
16 R. E. Wager—Nature Study Review, 1916.

I am a Chemist*

Berton Bellis.

I have provided work, brought about prosperity, laid the foundation of the fortunes of many people and sowed the seed of commercial prosperity—broadened commerce—and improved the material conditions of man himself and those who care for him and his possessions.

I am one of the oldest of sciences, the first to be recognized and utilized by man.

I am of the profession that has given many martyrs to humanity's cause of peace, progress, and better living conditions.

I am always investigating—experimenting—and trying to expose the hidden secrets of the different material elements and remove all doubts to the goodness and wisdom of God, the omnipotent creator of all things.

I am always at the mercy of burning acids, explosions, diseases, blindness, and death.

I am the creator of the laboratory that guards man against famine, disease, destruction, and untimely deaths.

I place the various ingredients of the universe under the microscope, and in the test tubes, and am at home with the living germ —or the units of matter, the molecules, the truants of the naked human eye, the atom and the electron.

I take nourishment from the atmosphere and plant it in the arid soil thereby enabling man to cultivate and raise a greater abundance of food.

I create and make the synthetic materials to take the place of materials vanished from the earth.

I find the evidence of crime in the test tube and under the microscope—and am a great factor in criminology.

I turn the forests into pulp from which paper is manufactured and I make materials into ink and refine the steel of which printing presses are made, thereby helping man to collect and publish the latest news and promote education and learning.

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*Reprinted from "The Crucible."

I invent and make the paint with which the master artist touches the canvas with his magic brush and produce almost living, speaking pictures.

I am of the profession that has caused many a man to go to an untimely grave because of the lack of knowledge and appreciation of my principles and secrets.

I am the one who has found a monument in man's living conditions that have been constantly improved by my comrades for ages and eons.

I open new countries in the arid districts and destroy pests, check the ravage of pestilences, and turn the barren and unproductive lands green with abundant verdure.

I make the ingredients for the healing balsam, the drugs, the vaccine, virus, the serum, and all other nostrums that relieve sick and distressed humanity.

I make the coloring for man's robes and beautify the smile of "my lady" fair and make perfumes of the earth that rival the most fragrant and bewitching rose that the cultivation of man ever produced.

I lengthen man's span of years by purifying the water that he drinks and enabling him to make his foods more wholesome.

I account for action and reaction—composition and decomposition—and all changes made in the workings of the natural forces and matter.

I can make war and carnage so destructive and terrible that mankind will be compelled to live in peace because if he does not, the entire race will be annihilated.

I am man's benefactor for long life, peaceful pursuits, foods in plenty, and the stimulus to traffic and commerce.

As man travels from the cradle to the grave I am his benefactor, helper, and conserver and even preserve his mortal body for future generations and history.

I am a chemist.

Types of Thought Questions in General Science Text Books and Laboratory Manuals

Harry A. Cunningham, The University of Kansas.

Some four years ago, when I was principal of a high school in central Illinois, I received, from the Bureau of Educational Research of the University of Illinois, a bulletin giving twenty different types of thought questions. The purpose of the bulletin was to find out the extent of the use of the different types of thought questions in actual school practice and to get the teachers' judgment of the relative difficulty of the different types. Many of us, who received that questionnaire, had never before been conscious of the fact that there were so many definite and distinct types of thought questions. In practice, we had been using a very few types, such as, "pure memory," "discuss," and "selective recall." During the past summer, I assigned my class in the "Teaching of General Science" the task of finding out what types of questions are most often used in general science text books and laboratory manuals. All except the first two types of questions are taken from the Illinois bulletin. The list follows:

1. Pure memory questions.
2. Questions involving observation only.
3. Selective recall—basis given.
4. Compare two things on a single designated basis.
5. Compare two things in general.
6. Decision—for or against—choice or preference.
7. Give causes or effects.
8. Explain the use or meaning of some phrase or statement in a passage.
9. Summarize—some unit in the text, article read, or experiment performed.
10. Analyze. (The word itself is seldom involved in the question.)
11. State relationships.
12. Classify. (Usually the converse of 18.)
13. Give illustrations or examples (your own) of principles.
14. Evaluating recall—basis given.

15. Suggest or make applications of rules or principles in new situations.

16. Discuss.

17. Questions of aim—author's purpose in his selection or organization of material.

18. Criticize some statement—as to adequacy, correctness, or relevancy of a printed statement.

19. Give a brief outline.

20. Reorganize facts learned in one organization on a new basis. (A good type of review question to give training in organization.)

21. Questions on new methods of procedure.

22. Questions on problems and questions raised. What question came to your mind? What else would have to be known in order to understand the matter under consideration? etc.

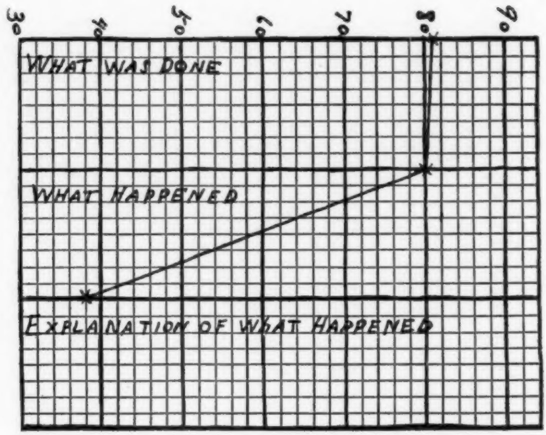
In the following table we have represented the number of questions of each type occurring in ten general science text books and laboratory manuals. In the table below, A. C. E. G. H. I, and J represent text books; B, D, and F, represent laboratory manuals.

From the table, we can see that more than one half of all the questions involved in this study are either pure memory questions or observational questions. Observation is an important step in scientific thinking and the step which natural science is best able to give, but it must be looked upon as only one step in a process and not as an end in itself. If our training goes no further than the development of memory and observational powers, we cannot expect to give efficient training in scientific thinking. Are we really training students to think scientifically?

For two years, I gathered data, from four classes in natural science, bearing upon this point. Practically all laboratory experiments were written up under three headings: (1) what was done; (2) what happened; (3) an explanation of what happened. For each experiment, the number of points that should be included in a complete "write-up" under each heading was listed. The number of points made by each individual, under each heading, was then counted and the score under each heading was calculated by dividing the number of points made by the student by the number that should have been made. The accompanying graph shows the total scores made, under such a procedure, by two classes during one year of work. This graph is typical of all the graphs that I have seen bearing upon this point.

GENERAL SCIENCE TEXT BOOKS AND LABORATORY MANUALS.

Types of Questions	A	B	C	D	E	F	G	H	I	J	Totals
1	5.5	42.0	908.0	5.0	24.0	17.0	33.5	8.5	195.0	4.0	1242.5
2	198.0	430.5	1708.0	80.0	64.0	168.0	117.0	382.0	420.0	20.0	3587.5
3	24.5	64.3	229.0	7.0	16.0	12.0	33.5	27.0	75.0	4.0	492.3
4	18.0	41.3	45.5	0.0	5.0	13.0	23.0	8.5	30.0	0.0	184.3
5	41.0	29.3	27.5	19.0	0.0	38.0	13.5	3.0	15.0	51.0	237.3
6	16.5	130.0	69.0	16.0	4.0	2.0	15.5	7.5	32.0	0.0	292.5
7	51.0	53.6	115.0	33.0	12.0	52.0	21.0	27.0	45.0	0.0	409.6
8	19.0	25.5	1.0	13.0	8.0	7.0	37.5	1.5	25.0	0.0	137.5
9	20.5	4.5	55.5	4.0	6.0	10.0	2.0	14.0	8.0	4.0	128.5
10	18.0	248.6	20.0	0.0	0.0	80.0	9.0	109.5	10.0	0.0	495.1
11	9.0	112.6	7.0	0.0	6.0	1.0	11.5	8.0	40.0	0.0	195.1
12	19.0	49.0	16.5	0.0	0.0	0.0	2.0	.5	15.0	4.0	106.0
13	4.5	72.0	79.0	9.0	10.0	1.0	1.5	.5	31.0	0.0	208.5
14	29.0	89.0	16.0	3.0	8.0	0.0	12.0	33.5	16.0	0.0	206.5
15	29.0	40.6	59.0	9.0	56.0	0.0	16.0	15.0	150.0	1.0	375.6
16	3.5	5.0	72.5	0.0	15.0	0.0	5.0	0.0	13.0	28.0	142.0
17	0.0	2.6	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	12.6
18	4.0	1.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5
19	2.0	9.0	44.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5
20	11.0	5.3	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	17.3
21	17.5	26.3	20.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	65.3
22	2.5	136.0	47.5	0.0	0.0	0.0	0.0	0.0	250.0	0.0	436.0
Totals for each book	543.0	1618.0	3546.0	208.0	234.0	401.0	355.0	647.0	1370.0	116.0	9038.0



Graph No. 1—The type of graph obtained when laboratory work is written up and scored under the headings given in Graph.

Under "what was done," we are dealing mostly with memory. Under "what happened," observation is the important thing. Under the "explanation," scientific thinking is the factor most important. It would seem that we are succeeding fairly well in giving training in memory and observation. Scientific thinking is the thing that is lacking. We, as science teachers, are evidently making an absolute failure in our efforts to attain one of the important aims of natural science teaching. Why are we failing?

From a study of the accompanying table, it is clear that writers of text books and laboratory manuals are absolutely unconscious of the fact that there are many different and distinct types of problems. Teachers, as a group, are, of course, much less aware of types of problems, if such a thing can be possible.

In general science, we often have a student jot down a point or two in answer to a question and then settle back in his seat thinking his task is done. When his attention is called to the fact that his answer is very incomplete and when the points that should have been included are mentioned, he very often says, "Why, I knew that." What, then, was the trouble? In many such cases, the trouble is not a lack of knowledge of the subject but the lack is in not knowing what is involved in a complete answer to a problem of the particular type under consideration. Such a student needs training in restating his problems and in breaking them

up into questions. He needs to have in mind just how to proceed to give a complete answer to a "selective recall" question; to a question involving cause and effect; to a question in which two things must be compared "on a single designated basis"; and even when he is asked to discuss a topic. He needs training in best methods of solving his problems.

We, as teachers, need not only to be conscious that there are a very great number of types of problems but we need to be conscious that there is a best method to follow in solving each type. We need, furthermore, to know definitely just what that best method is, When this consciousness has once dawned upon us, as teachers, we need to pass it on to our students in natural science. Before they leave us, they should have stored away in their minds samples of the various types of problems and samples of the best method to follow in solving each type; so that, when they get out into the world, they will be more able to classify the problems of life as they arise and use the best method in their solution. This, of course, means training in the ability to recognize the identical elements in different situations.

Teachers of secondary school pupils must become students of mental processes. Much time must be spent in determining just what study skills and abilities are necessary for our particular subject. After these skills and abilities have been settled upon, we must take these as our objectives and use our subject matter in order to attain them. When such an attitude toward our teaching job is adopted, many of our present methods of selecting and organizing subject matter will be changed and our class room technique will be revolutionized. By some such procedure, we shall go far in advancing the pedagogy of natural science teaching, and in discovering the mental processes involved in scientific thinking.

The Fifth Estate*

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Benjamin Franklin was not perhaps in all respects a paragon, but he was unquestionably a polygon—a plain figure with many sides and angles. There were not enough buttons on his black coat to tell off the multifarious aspects in which his complex personality was presented to the world. He was craftsman and tradesman; philosopher and publicist; diplomat, statesman, and patriot. And he was, withal, a very human being. What concerns us particularly on this occasion is the fact that he was at once philosopher and man of affairs. His remarkable career should refute forever the fallacy, which, unfortunately, still is current, that the man of science is temperamentally unfitted for the practical business of life.

At the time when Franklin was in England the British Parliament was assumed to be composed of representatives of three estates—the lords spiritual, the lords temporal, and the commons; but Edmund Burke, pointing to the Reporters' Gallery, said, "There sits a *Fourth Estate,* more important far than they all." No one at all familiar with the ubiquitous influence and all-pervading power of the press would today question the validity of Burke's appraisal. Even then, however, there was present in England, in the person of Benjamin Franklin, a prototype and exemplar of the membership of a *Fifth Estate*—an estate destined to play an even greater part than its predecessors in the remaking of the world.

Its Membership.

This Fifth Estate is composed of those having the simplicity to wonder, the ability to question, the power to generalize, the capacity to apply. It is, in short, the company of thinkers, workers, expounders, and practitioners upon which the world is absolutely dependent for the preservation and advancement of that organized knowledge which we call science. It is their seeing eye that discloses, as Carlyle said, "the inner harmony of things; what

*Delivered at the Centenary celebration of the founding of the Franklin Institute and the inauguration exercises of the Bartol Research Foundation, Philadelphia, Pa., September 19, 1924. Published in "Journal of The Franklin Institute" (Nov., 1924), The "Atlantic Monthly" (Dec., 1924), and "Industrial and Engineering Chemistry" (Nov., 1924).

Nature meant." It is they who bring the power and the fruits of knowledge to the multitude who are content to go through life without thinking and without questioning, who accept fire and the hatching of an egg, the attraction of a feather by a bit of amber, and the stars in their courses, as a fish accepts the ocean.

The curious deterioration to which words are subject has left us with no term in good repute and common usage by which the members of the Fifth Estate may properly be characterized. Sophists are no longer distinguished for wisdom: they are now fallacious reasoners. Philosophers, who once claimed all knowledge for their province, are now content with speculative metaphysics. Scholars have become pupils. The absent-minded and myopic professor is a standardized property of the stage and screen. The expert, if not under a cloud, is at least standing in the shade. In Boston one hesitates to call a professional man a scientist—he may be a Presbyterian; and a "sage," as an anonymous writer has pointed out, "calls up in the average mind the picture of something gray and pedantic, if not green and aromatic." Let us, therefore, for a time at least, escape these derogations and identify ourselves as members of the Fifth Estate.

Although the brotherhood of the Estate is open to all the world, its effective membership nowhere comprises more than an insignificant proportion of the population. Two hundred and fifty constitute the membership of the National Academy of Sciences. The latest edition of "American Men of Science" includes only about ninety-five hundred names. The number is expanded to twelve thousand eight hundred on the roll of the American Association for the Advancement of Science. Although gathered from all countries and though chemistry is one of the most active and inclusive sciences, the chemical papers, books, and patents reviewed in *Chemical Abstracts* in 1923 were the product of about twenty-two thousand workers. One may hazard the estimate that there are not in all the world one hundred thousand persons whose creative effort is responsible for the advancement of science.

ITS ORIGINS.

The studies of Cattell indicate that in America, at least, the great majority of men of science come from the so-called middle and upper classes, or precisely those sections of society which in Russia have been practically exterminated in the name of the new Social Justice. In about two-thirds of Cattell's reported cases

both parents were American-born, while the fathers of nearly one-half were themselves professional men. Seventy-five per cent are dependent upon the universities for support, from which we may assume that the burden of the higher surtaxes does not bear heavily upon the Fifth Estate.

In proportion to population the cities have produced twice as many scientific men as the country, but how many "hearts once pregnant with celestial fire" repose in country churchyards because of lack of opportunity and absence of the stimulus of contact, cannot, of course, be known, nor can we tell how many brains, competent and equipped to penetrate the mysteries of nature, the war has cost the world.

Initiative is one of the rarest mental qualities, yet without it progress is impossible. Its combination with the scientific imagination and command of fact is still rarer and more precious. Since comparatively few of those who study science develop the capacity to extend its borders, the cost of a man competent to advance science has been estimated at five hundred thousand dollars and his value to the community set at a far greater figure. Full membership in the Fifth Estate thus seems to involve the highest initiation fee on record. It is a figure disconcerting to the candidate, but as Wiggam has finely said, "Only genius can create science, but the humblest man can be taught its spirit. He can learn to face truth."

ITS TERRIFYING LANGUAGE.

That the Fifth Estate is not better appreciated or always understood by the world at large is not surprising. In their endeavors to secure accuracy of definition and expression its members have evolved a preposterous and terrifying language of their own. It is not ideally adapted to the interchange of confidences in ordinary human intercourse. It does not lend itself to poetry. "Ladybird, ladybird, fly away home" becomes impossible when one is forced to address the prettily spotted beetle as *Coccinella dipunctata*. A primrose by the river's brim is much more than a yellow primrose to the botanist: it is a specimen of *Primula vulgaris*. The organic chemist produces a new synthetic product in a mass of pilular dimensions and bestows upon it a name that would slow up Arcturus. Nothing but static interference can account for the terms of radio telephony. If knowledge is to be humanized it must first be translated.

Dewar has said that the chief object of the training of a chemist is to produce an attitude of mind. It should be the object of all education to produce the scientific attitude toward truth. We may even agree with Robinson that "of all human ambitions an open mind, eagerly expectant of new discoveries and ready to remold conviction in the light of added knowledge and dispelled ignorances and misapprehensions, is the noblest, the rarest, and the most difficult to achieve."

Carlyle says, "The degree of vision that dwells in a man is a correct measure of the man." And President Coolidge has been quoted as saying in a recent interview:

"Everything flows from the application of trained intelligence, and invested capital is the result of brains.

"The man of trained intelligence is a public asset.

"We go forward only through the trained intelligence of individuals, but we, not the individuals, are the beneficiaries of that trained intelligence. In the very nature of things we cannot all have the training but we can all have the benefits."

Now vision, a trained intelligence, and an open mind are the qualities which characterize all those who are worthy of membership in the Fifth Estate. They are qualities which the many-sided Franklin possessed in exceptionally high degree.

FRANKLIN, ITS PROTOTYPE.

Among all the activities with which his busy life was crowded, Franklin undoubtedly found his greatest pleasure in the pursuit of science, and in that pursuit he followed the eclectic method. At a time when nearly everything awaited explanation his focused attention ranged like a searchlight over many fields. He observed the movement of winds and developed a theory of storms. He considered ventilation and the causes of smoky chimneys and proceeded to invent new stoves. He introduced the Gulf Stream to Falmouth skippers and demonstrated the calming effect to oil on turbulent seas to officers of the British Navy at Portsmouth. From earthquakes he turned to the heat absorption of colored cloths and the fertilizing properties of gypsum. He wrote on sun spots and meteors; waterspouts, tides, and sound. The kite, which for centuries had been the toy of boys, became in Franklin's hands a scientific instrument, the means to a great discovery. That its significance is, even now, not universally appreciated is shown by the recent answer of a schoolboy, "Lightning differs from elec-

tricity because you don't have to pay for lightning." To Franklin, as the child of every man knows, we owe our initial conceptions of positive and negative electricity, and he was the first to suggest that the aurora is an electrical phenomenon.

The gregariousness which is a prominent characteristic of the Fifth Estate found early expression in Franklin. He formed The Junta, a club for the discussion of morals, politics, and natural philosophy, and in 1744 drew up a proposal for the organization of the American Philosophical Society, of which later he became president. He established a wide acquaintance and cemented many firm friendships among the foremost scientific men of France and England, by whom he was received on equal terms. In 1753 he was awarded the Copley Medal of the Royal Society for his discoveries in electricity, and on his leaving England, David Hume wrote: "I am sorry that you intend soon to leave our hemisphere. America has sent us many good things, gold, silver, sugar, tobacco, indigo, but you are the first philosopher and indeed the first great man of letters for whom we are beholden to her."

Its Spirit of Service.

The professional spirit which animates the Fifth Estate is essentially one of service. Its compelling urge in the search for truth springs from the conviction that the Truth shall make men free. That spirit finds complete expression in Franklin's statement: "I have no private interest in the reception of my inventions by the world, having never made, nor proposed to make, the least profit by any of them." This impersonal relation to the children of his brain was indeed carried by him to an extent which ordinary human nature would find hard to emulate. "I have," he writes, "never entered into any controversy in support of my philosophical opinions; I leave them to take their chance in the world. If they are right, truth and experience will support them; if wrong, they ought to be refuted and rejected." There is, nevertheless, a place for militancy in science. The world needs a Huxley for every Bryan.

Franklin was a man of science, but his career proclaims that it is possible to be a man of science and much more besides. Science was made for life, and life is more than science. Art in its fullest expression may touch deeper springs; human relations and affections may bring richer rewards, and public affairs may make a more imperious claim. With Franklin as their prototype the mem-

bers of the Fifth Estate may well strive to emulate his devotion to the public service and his broad and constructive interest in human problems and affairs.

Error and misconception have a feline tenacity of hold upon life, and the Fifth Estate, though richly endowed with latent executive capacity, is still in popular opinion regarded as equipped for thought rather than for action. The practical man, busily engaged in repeating the errors of his forefathers, has little time and less consideration for the distracting theories and disconcerting facts of the man of science. Yet who, among the men of action, is more intensely and truly practical than Carty, Baekeland, Reese, or Whitaker? Where shall one find a firmer grasp on the details of business than that possessed by E. W. Rice, Jr., Gerard Swope, or Dr. Nichols? What quality caused the young director of a research laboratory to find himself responsible for the production of gas masks to protect four millicn fighting men? In a time of dire emergency it was a professor of chemistry who organized the great Edgewood Arsenal and developed the means and methods and the trained personnel required to supply munitions for a new type of warfare. It was not to a statesman or a business man or a great manufacturer that the Allies entrusted the supreme command. It was to a teacher in a French military school. The range and value of their public service obscures the fact that Charles W. Eliot was a professor of chemistry and that Hoover is an engineer. The League of Nations is the child of a schoolmaster.

Numerically, the Fifth Estate has always been feeble and insignificant. Its total membership at any time could be housed comfortably in a third-rate city. No politician makes a promise or invents a phrase to attract its scattered and ineffective vote. Rarely do its members sit in Congress; when they do, they sit in the gallery.

ITS ACCOMPLISHMENT.

With less political influence than the sparse population of Nevada the Fifth Estate has recast civilization through its study and application of "the great and fundamental facts of Nature and the laws of her operation." It has opened out the heavens to depths beyond imagination, weighed remote suns and analyzed them by light which left them before the dawn of history. It has moved the earth from the center of the universe to its proper place within the cosmos. It has extended the horizon of the mind until its

sweep includes the thirty thousand suns within the wisp of smoke in the constellation Hercules and the electrons in their orbits within the atom. It has read the sermons in the rocks, revealed man's place in nature, disclosed the stupendous complexity of simple things, and hinted at the underlying unity of all.

Because of this new breadth of vision, this lifting of the corner of the veil, this new insight into the hidden meaning of the things about him, the mind of man, cramped for ages by taboos and bound by superstition, is emerging into freedom; into a new world, rich in promise and of surpassing interest and wonder.

Man brought nothing into the world and through long and painful ages he added little to that nothing: a club, an ax of stone, a pebble in a sling, some skins of beasts, a rubbing of sticks for a fire. He might labor, but to what avail? Even today the South American Indian works incessantly; yet his labor produces little more than heaps of stones. To those who would have us believe that all wealth is produced by labor the Fifth Estate replies, "Wealth is the product of brains, and labor is productive only as it is guided by intelligence."

THE EMANCIPATOR OF LABOR.

Science is the great emancipator of Labor. Bagehot has somewhere said, perhaps in "Physics and Politics," that during the early stages of civilization slavery was essential to progress because only through the enforced labor of the many could the few have leisure to think. Today, in the United States, the supply of available energy is equivalent to sixty-man power for every man, woman, and child. There is now leisure for all to think, but the millions prefer the movies.

It is not Labor, but the trained intelligence of the Fifth Estate which has endowed man with his present control of stupendous forces. It has solved problems that for ages have hindered and beset mankind. It has revealed great stores of raw materials, synthesized scores of thousands of new compounds, furnished the fundamental data which find embodiment in machines and processes and in those agencies of transportation and communication that have made of the world a neighborhood. It has enabled man effectively to combat disease, added years to the average life, and made it better worth the living.

Could Franklin Return!

Benjamin Franklin died in 1790—one hundred and thirty-four years ago. Could he return to make appraisal, what wonders would confront his astonished vision, what triumphs of the Fifth Estate compel his admiration!

Electricity, which to his contemporaries was little more than an obscure force, the curious manifestations of which might supply an evening's entertainment, has become the structural basis of the universe. The atom of Democritus is now a microcosm, vibrant with energy that glows in the white light of the electric lamps, which have replaced the tallow dip. In place of the electrophorus and the charges of the Leyden jar he would find in our own country alone twenty-seven million horsepower driving generators in thousands of stations, from which electric energy is distributed to our homes and factories and transportation lines to perform innumerable services. Imagine, if you can, the stunning impact of the impressions that would crowd the day of his return. With what amazement would he converse over a wire from Philadelphia to San Francisco or hear a voice transmitted through the ether from a point halfway around the world. So commonplace a thing as a street car would leave him open-mouthed with wonder, which might well increase at sight of an electric locomotive, hauling its hundreds of tons of freight.

In great industrial plants he would find electricity driving machines of an intricacy, precision, and productive power beyond the imagination of his generation, or at work in decomposing cells and in the heart of glowing furnaces fashioning new products. In university and corporation laboratories would be revealed to him the marvels of the X-rays, photography, the fascinating world of the microscope, balances weighing 1/100,000th of a milligram, the spectroscope, and all those instruments of precision and research which are the tools of the Fifth Estate. Elements unknown to him would be placed in his hand; fascinating experiments performed to demonstrate properties and relationships beyond his dream. The air, which he studied with reference to winds, combustion, and ventilation, would be reduced before him to a liquid as obvious as water, though boiling on a cake of ice.

Where once the post boy and the post chaise were familiar he would find our roads crowded with automotive vehicles and the country gridironed by the railways. Did he wish to send a letter

across the continent, he would have only to commit it to the air mail to insure its arrival in thirty-six hours. Were he called upon to revisit England, there would be no ten-week voyage in a sailing packet, but the speed and luxury of a fifty thousand ton liner, oil fired and turbine driven. At Portsmouth, where he calmed the waves with oil, he would find, instead of wooden frigates and smooth-bore cannon, submarines and armored superdreadnaughts, a single gun of which sink the entire British Navy as he knew it. Did he wish to proceed to Paris, he would have only to take passage in an airplane.

HEREDITY AND PEAS.

The gardeners Franklin knew grew peas for pleasure or profit. Mendel grew them and established the laws of heredity. Farming, which was a wholly empirical occupation, is now the special concern of a great governmental department devoted to the development of scientific agriculture. Here Franklin would learn of soil analysis and seed selection, of hardier and more prolific varieties of plants, of better breeds of animals, of methods of control of such virulent diseases as splenic fever, anthrax, hog cholera, and bovine tuberculosis. He would find his own experiments with gypsum extended to cover the whole field of chemical fertilizers, the air itself converted into an inexhaustible reservoir of plant food, and the efficiency of farm labor multiplied many times by ingenious agricultural machines.

He would find household economics revolutionized: the town pump replaced by running water; electricity a servant in the house; the food supply broadened and stabilized; domestic drudgery assumed by laundry, bakery, and factory; tasteful clothing within the reach of all; transportation and amusement for the multitude; and the history of yesterday sold for a penny. Innumerable new industries, based on the findings of the laboratory, now offer the means of decent livelihood to millions and open careers to thousands.

In great hospitals, permeated with the scientific spirit and equipped with many new and strange devices for the alleviation of human suffering, he would hear of the incalculable benefits which medical and surgical science have conferred upon mankind. He would see the portraits and listen to the story of Pasteur and Lister and Loeb and Ehrlich. We know today with what joy and relief the world would welcome a veritable cure for cancer,

but we can little realize the emotion with which one like Franklin would learn in a single afternoon of the germ theory of disease, of preventive serums, of antisepsis, of chemotherapy, of the marvelous complexity of the blood stream, and the extraordinary influence and potency of the secretions of the ductless glands. What appraisal would he make of the service to humanity which, in little more than a generation, has mitigated the horrors of surgery by the blessings of anesthesia and antisepsis; which has controlled rabies, yellow fever, typhoid fever, tetanus; which is stamping out tuberculosis, curing leprosy, and providing specifics for other scourges of the race. What values would he put on insulin, thyroxin, adrenalin? The physician is no longer compelled to rely on herbs and simples and drastic mineral compounds of doubtful value and uncertain action. Compounds of extraordinary potency, isolated or synthesized by the chemist, are now available to allay pain correct disorders, prolong life, and even to restore mentality and character.

CHEWING GUM *vs.* RELATIVITY.

With contributions to their credit, which have so enriched and stimulated the intellectual life; which have brought the peoples of the earth together into closer touch than English shires once were; which have revolutionized industry, enlarged the opportunity of the average man, and added so greatly to his comfort and well-being, we may reasonably inquire, "What are the recompenses of the Fifth Estate?"

On the material side they have almost invariably been curiously inadequate and meager. It is incomparably more profitable to draw "The Gumps" for a comic supplement than to write "The Origin of Species." There is more money in chewing gum than in relativity. Lobsters and limousines are acquired far more rapidly by the skilful thrower of custard pies in a moving-picture studio than by the no less skilful demonstrator of the projection of electrons. The gate receipts of an international prize fight would support a university faculty for a year.

One may recall that Lavoisier was guillotined by a republic that "had no need of chemists," that Priestley was driven from his sacked and devastated home, that LeBlanc, after giving the world cheap alkali, died in a French poorhouse, that Langley was crushed by ridicule and chagrin in his last days. A month before the war who could have believed that within a few years the Fifth Estate

in Russia would be utterly destroyed and in Germany and Austria existing at the very edge of starvation. What has happened there may happen again elsewhere if the intelligence of the world does not assume and hold its proper place in the direction of national and world affairs.

In the preface to his recent "Lehrbuch der Photochemie," Professor Plotnikow has written: "Home and property were pillaged by bands of idle Russians who used my library for cigaret papers. Hunger, misery, want, and personal insecurity, often approaching fear for my life, were the constant accompaniment of my labors."

One is reminded that Carlyle, on the authority of Richter, says: "In the Island of Sumatra there is a kind of 'Light-chafers,' large Fire-flies, which people stick upon spits, and illuminate the ways with at night. Persons of condition can thus travel with a pleasant radiance, which they much admire. Great honor to the Fire-flies, but——!"

It is not becoming that the world expect the light to shine indefinitely, when carrying a lantern is often less remunerative than carrying a hod. The money and the years of study required for special training are not recognized as invested capital, and the return from a decade of research is often taxed as the income of a year. Professorial salaries move forward as slowly as a glacier, but they seldom leave a terminal moraine. Yet teaching is our most important business, for a failure to pass on for a single generation the painfully accumulated knowledge of the race would return the world to barbarism.

Though material wealth is rarely acquired by the Fifth Estate, they have the riches of the royal man, defined by Emerson as "he who knows what sweets and virtues are in the ground, the waters, the plants, the heavens, and how to come at these enchantments." Their wealth is in the Kingdom of the Mind. It is inalienable and tax-exempt. It may be shared and yet retained.

A recent survey by a national magazine would seem to indicate that the majority of men have drifted into their vocations with little effort of selection and that a very large proportion ultimately regret their choice. This is seldom true of members of the Fifth Estate. Theirs is a true vocation, a calling and election. It brings intellectual satisfactions more precious than fine gold. They live in a world where common things assume a beauty and a meaning veiled from other eyes; a world where revelation follows skilful

questioning and where wonder grows with knowledge. Together they share the interests, the communion of spirit, the labors and the triumphs of the fraternity of Science. The Law of Diminishing Returns exerts a control from which there is no escape in agriculture, industry, and business. Research alone is beyond the twelve-mile limit of its inhibitions.

THE SPIRITUALITY OF SCIENCE.

If "the Heavens declare the glory of God," that glory is surely made more manifest by telescope and spectroscope. If the whirling nebulae and the stars in their courses reveal omnipotence, so do the electrons in their orbits reveal His presence in universes brought into being by the striking of a match. The laboratory may be a temple as truly as the church. The laws of Nature are the Will of God, their discovery is a revelation as valid as that of Sinai, and by their observance only can man hope to come into harmony with the universe and with himself.

There has been a general and ready acceptance by the world of the material benefits of science, while its contributions to sociology and ethics are as generally ignored as guides to human conduct. Yet science proclaims new commandments as inflexible as those engraved on stone and furnishes what Wiggam has reverently termed "the true technology of the Will of God."

SCIENCE AND POLITICS.

Science has so drawn the world together and so rapidly remolded civilization that the social structure is now strained at many points. Statecraft and politics, law and custom lack the plasticity of science and are now in imperfect contact with the contours of their new environment. The result, as events have shown, is friction and confusion. Though our civilization is based on science, the scientific method has little place in the making of our laws. Office does not seek the man in the laboratory, and candidates are not pictured as engaged in any activity that might suggest a superior intelligence. They are shown milking cows, pitching hay in new blue overalls, or helping with the family washing. Recently, in the senate of a New England state, there was presented the edifying spectacle of the presiding officer being shaved by a barber, called to the rostrum, while senators were reading the encyclopedia into the record. To expedite further the public business sundry members of the chamber were presently gassed with bromine.

Does not this suggest that a few chemists might with advantage be distributed among our legislative bodies?

It is claimed that fifty per cent of the members of state legislatures in America have never been through high school and that only one in seven has been through college. We see in the ranks of science knowledge without power and in politics power without knowledge. An electorate, which regards itself as free, listens to the broadcasted noise of manufactured demonstrations and is blind to the obvious mechanics of synthetic bedlam. The result is too often government by gullibility, propaganda, catchwords, and slogans, instead of government by law based on facts, principles, intelligence, and good will.

As President Stanley Hall once said, "Man has not yet demonstrated that he can remain permanently civilized." Many thoughtful people have been led to question the utimate effect of science upon civilization. We all recognize the utility of matches, but we keep them away from children. Meanwhile, science puts dynamite and TNT, poison gas, airplanes, and motor cars at the disposal of criminals and the leaders of the mob. Russell, in "Icarus," sees in science the ultimate destroyer. Haldane, in "Daedalus," visualizes it as the stern and vigorous chastener and corrector which will ultimately save the race and usher in the new day of light and reason.

"Knowledge comes but Wisdom lingers," and Democracy levels down as well as up. Even in Boston cigars have replaced books on a corner famous for a century of literary associations. The world is wrong because few men can think. It will not be made right until those who cannot think trust those who can. When its foundations are so obviously out of joint humanity still clings tenaciously to fossilized precepts and opinions and is as resentful of suggested change as in the days of Galileo. Despite the pressure of new ideas, education must still, to be acceptable, follow old conventional lines.

The World as It Is

Let us not deceive ourselves. Human life is still a hard and fearsome thing. Mankind is required to maintain existence in a world in which, as Kipling has said, "any horror is credible." More than a hundred years ago De Quincey wrote: "We can die, but which of us, knowing as some of us do, what is human life, could, were he consciously called upon to do it, face, without

shuddering, the hour of birth." But little more than yesterday Henry Adams closed his "Education" with the expression of the hope that perhaps some day, for the first time since man began his education among the carnivores, he would find a world that sensitive and timid natures could regard without a shudder.

Everywhere there is upheaval and unrest. "The machine," to quote Dr. Elton Mayo, "runs to an accompaniment of human reverie, human pessimism, and sense of defeat."

We are everywhere overburdened by unnecessary illness, crushing taxation, extravagant and inefficient governments, huge expenditures for trivialities, and the appalling waste of effort, material, and resources. We are hampered by class suspicion and misunderstanding, racial antagonisms, the inhibitions of organized labor, and the lack of imagination in high places. Life in general is on a low cultural plane and bound by custom and tradition.

One hundred years of science have failed to satisfy the cravings of humanity. Chesterton finds science "a thing on the outskirts of human life—it has nothing to do with the center of human life at all." We do not, of course, agree with him, but we must still meet the challenge of John Jay Chapman, who declares: "Science, which filled the air with so large a bray, is really a branch of domestic convenience, a department for the study of traction, cookery, and wiring. The prophet-scientists have lived up to none of their prospectuses." The fault, however, as Wiggam points out, is not with science, nor with the scientists. It is with those who "have mainly used the immense spiritual enterprise of science to secure five-cent fares, high wages, and low freight rates," when it should have "ushered in a new humanism."

Thus we still encourage race deterioration, still carry the burden of the unfit, still cultivate national antipathies, still are breeding from poor stock, and witnessing with equanimity the suppression of the best.

The history of aristocracies, feudalism, the church, the guilds, and the soviets has amply demonstrated that no one class possesses the qualities required for the government of all classes, and we cannot claim them for the Fifth Estate. We can, however, claim with full assurance that the Fifth Estate possesses many qualities, now practically ignored, which could be utilized in government to the incalculable advantage of us all. Its knowledge of material facts, of natural and economic laws, of the factors governing race

development and human relations; its imagination, vision, and its open mind should be brought to bear effectively in the formulation of national policies and the solution of governmental problems. There is an alternative before us, which has recently been defined with somewhat surprising frankness by Warren S. Stone, president of the Brotherhood of Locomotive Engineers, perhaps the most conservative of the labor unions. Mr. Stone says:

"But until labor, in the inclusive sense in which I am using it, secures control of legislative and executive branches of the national and state governments, and through control of the executive branch secures control of the judiciary, labor is in continuous peril of seeing its gains wiped out and its progress retarded, by hostile legislation or unfriendly court decisions."

Our countrymen may well consider whether they prefer participation in government by the Fifth Estate to the benefit of all or control of government by labor unions in the interest of labor.

THE WORLD AS IT MIGHT BE.

Since most of the troubles that beset mankind have their origin in human nature, it would seem worth the while of those who make our laws to study and apply the findngs of the biologists as to what Human Nature really is and the springs of its motivation.

Plato called Democracy "the best form of bad government." It will be the best form of good government only as it develops the capacity to breed leaders and the faith to trust them. The quality of our children will determine the quality of our democracy. If our laws and *mores* and economic structure continue to discourage breeding from our best strains, if there is to be no adequate recompense for service of the higher types, the time is not far distant when Democracy will not longer be safe for the world. If the Fifth Estate were everywhere to be wiped out, as it has been in Russia, the result would be vastly more calamitous than universal war.

Oswald Spengler, in a recent monumental work, forecasts the Downfall of Western Civilization and would prove his thesis by the history of past cultures. But never in the past has man lived in so compact a world, never has he had such facilities for intercommunication with his fellows, never has he been endowed with such control of natural forces. He has never known himself so well and, above all, never before has he had it in his power to direct so definitely the course of his own development. Our civ-

ilization is certainly imperiled, but there will be no downfall if mankind can be taught to follow the light already before it. As lantern-bearers, it is the clear duty of the Fifth Estate to show the way. In the past the world has suffered grievously from lack of knowledge; today it suffers from its rejection or misapplication. Could the springs of human conduct and the affairs of peoples now be regulated only as wisely as we now know how, there would be work and leisure and decent living for all. The criminal, the defective, the feeble-minded would be breeded out, and sane minds in sound bodies breeded in. The loss and suffering from preventable disease and accident would not be tolerated. Higher standards would govern the selection for the public service. Planning would replace *laissez faire* development, and a rational conservation check the reckless waste of our resources. Production and distribution would attain to levels of efficiency altogether new, and the many injustices now existent in human relations would well-nigh disappear. With the reaction of a freed intelligence on politics, religion, morals, we might hope for a broader tolerance, a better mutual understanding. With the recognition of the spirituality of science and the divinity of research and discovery should come larger interests and a new breadth of vision to the average man, and to us all acknowledgment of the steadfast purposive striving shown in the development of the created world and a reverent appreciation of man's privilege to aid and further this development.

We might reasonably expect ugliness to be replaced by beauty in our cities and small towns and later even in our homes. Government by intelligence for the general good of all should supersede government by special interests, blocs, faddists, and fear of organized minorities and the uninformed crowd. With it all would come relief from the economic pressure, which bears so heavily upon the Fifth Estate that its children, which should be counted among the best assets of the community, are now a luxury.

The world needs most a new tolerance, a new understanding, an appreciation of the knowledge now at hand. For these it can look nowhere with such confidence as to the members of the Fifth Estate. Let us, therefore, recognize the obligation we are under. Ours is the duty and the privilege of bringing home to every man the wonders, the significance, and the underlying harmony of the world in which we live, to the end that all undertakings may be better ordered, all lives enriched, all spirits fortified.

The Secrets of Jack Frost Disclosed

O. E. Underhill, High School, Amesbury, Massachusetts.

The science class is looking out of the schoolroom window on a cold October morning.

Alice—Look at all the white frost on the grass.

John—Isn't it strange? I wonder where it comes from.

Alice—Perhaps it comes up out of the ground.

Mary—Here comes the teacher. We will ask him. He will tell us all about it. Teacher, where does all the frost on the grass come from?

Teacher—Where could it come from?

John—It might come from the ground.

Mary—Or the air.

Teacher—Sometmes frost is called frozen dew.

Charles—Then it must come from the air, because people say that dew **falls.**

Teacher—Yes, it comes from the air, Charles. Frost is not always frozen dew, though. Nor does dew always fall. If dew is formed on the grass and then the temperature falls below freezing, it would be frozen dew. Usually the frost forms directly on the blades of grass. The air near the grass becomes so cold that it cannot hold all the water vapor it has, and the water vapor is deposited on the surfaces of things. We call it dew. If the weather is cold enough so that the water vapor freezes as it is deposited we call it frost.

Beatrice—What makes the dew come out of the air?

Alice—The teacher just told you, Bea, that it came out when the air was too cold.

Beatrice—But why? What has the cold to do with it?

Teacher—Before I answer that question I wish to ask *you* a few in order to refresh your memories on one or two points. How much do you remember about what we found out about the air we breathe?

Charles—It is a mixture of a number of things: oxygen, and nitrogen, and—

Dora—And water vapor—

Earl—And bacteria and dust—

Beatrice—And carbon-dioxide.

Teacher—Yes, all the things you have named go to make up our atmosphere. Keep in mind the water vapor, and the dust, too. I think that before we are through with our talk the dust in the air will be mentioned again. Now do you remember what I have told you about molecules? What can you tell about them?

Alice—Everything is made up of small particles. The gases and water vapor of the air are made up of these particles. They are called molecules. They are always moving around and bumping into each other. The air has molecules of oxygen and molecules of nitrogen, and of carbon-dioxide, and of water vapor.

Teacher—Yes, that is quite right. What does heat do to these molecules?

Alice—It makes them move faster and bump harder.

Teacher—And what does heat do to water?

Dora—It makes it evaporate. Clothes dry quicker on a dry warm day than when it is cold.

Teacher—True. Heat gives the molecules of water more energy which is needed to change them from liquid form to vapor form. Warm air supplies more energy to water than cold air can and thus warm air will hold more water vapor than the cold air can. In a short time warm air in contact with water will have all the water vapor it can hold. Now if the air is again cooled, the molecules lose heat and the extra gaseous water molecules change back to liquid. These molecules of water vapor come together in groups until these groups become large enough to be seen and we have little droplets of dew.

Let us see if we cannot get some water vapor out of the air now. I will take this shiny nickle-plated can, fill it half full of water, and put a thermometer in it in order that you may be able to tell what the temperature of the water is. See, it is 20° C. now.[1] Now I will add ice a little at a time, stirring well after each addition.

Charles—See, the can is becoming cloudy.

Earl—There are drops of water on the outside of the can.

Dora—Is that the way dew forms?

Teacher—Yes. The cold can cooled the air near it, just as the earth, as it cools off, cools the air in contact with it, until the dew forms. Notice the temperature is now only 3°C. The temperature at which dew forms is called the dewpoint.[2]

Alice—What makes the plants cool off so that water is formed on them?

Teacher—When does dew usually form?

Alice—At night.

Teacher—Do you think the earth would be any warmer in the late afternoon than in the early morning?

Alice—Yes.

Teacher—Why?

Alice—The sun shining on the earth all day would warm it.

Charles—The sun's heat rays would come through the air without warming it, but when they strike the ground it would get warmer. You told us that the sun warmed the earth by radiant heat, and that that is the way heat travels by radiation.

Teacher—If that is true, why does not the earth keep getting hotter and hotter each day the sun shines?

Charles—After the sun goes down at night the warm earth cools off again.

Teacher—Yes, the heat is radiated from the ground and grass and other surfaces. Now you see that if the grass gives off its heat fast enough it may become so much cooler than the air in contact with it cannot hold all the water that it has picked up during the warmer part of the day, and dew is formed. You remember that today, in this room, dew formed at 3° C. If the earth cools enough to reach the freezing point, the water vapor may be deposited frozen on the blades of grass, or on your window; that is, frost is formed. Does anyone remember at what temperature water freezes?

Charles—32 degrees.

Teacher—Fahrenheit or Centigrade?

Charles—Fahrenheit. That is equal to zero degrees Centigrade.

Teacher—Now I am going to mix something with the ice (use calcium chloride) which will make the temperature lower than

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1 I believe that the metric system should be made familiar to boys and girls as soon as possible. Its advantages are of course obvious. By explaining why it is used by scientists and then continuously talking in it, mentioning the English approximate equivalents at the same time, I believe the pupil will become more familiar with it than by the usual practice of learning the metric tables. I have had many pupils in high school chemistry and physics who could glibly recite the tables but who could not think in the metric system at all.

2 From this point a discussion of humidity could easily be worked in.

zero. Now see, the temperature of this mixture is ten degrees below zero or the freezing point.

Dora—The water on the outside of the can has frozen.

Teacher—Yes. That would be frozen dew, if it were formed on the ground that way. Now I am going to pour this cold mixture into another shiny can which is dry on the outside. (Stir for two or three minutes.)

Alice—Oh! White frost is forming on the outside of the can.

Earl—The other night my mother said it felt like a frost, but father said "no" because it was too cloudy. What have clouds to do with a frost?

Teacher—The clouds form a blanket to keep the earth warm. The heat cannot radiate away as quickly so the earth does not become cold enough to form frost. Winds will prevent a frost from forming, too, for they mix up the warm air and cold air, so that the air near the earth doesn't have time to become cold enough to cause any water vapor to deposit. A fog might be said to be dew deposited in the air.

Mary—What cools off in the air?

Teacher—Name over again the things which are found in the air.

Mary—Oxygen, nitrogen, carbon-dioxide, water vapor, dust and bacteria.

Teacher—Yes. Sometimes it is the rust particles that cause the fog. The dust particles radiate their heat, become colder than the air, and water vapor condenses on them. Then we have the air filled with little particles of water so small and light that they are kept floating about in the air. Can anyone tell me of any other times when there is water in the air in particles so large that they can be seen?

John—Rain.

Mary—Mist.

Teacher—Yes. If the fog droplets are blown together, or unite with each other until they get nearly as large as raindrops we call it a mist. Where does rain come from?

Alice—The clouds.

Teacher—When the mist drops become heavy enough to fall we have rain. A fog or mist is merely a cloud resting on the earth. Do you remember when we were studying heat what we learned about hot air?

Charles—Yes. It rises.

Teacher—The earth becomes warmed by the sun as we have said before, and the air near it keeps fairly warm, but higher up the air is always quite cold. Now what would happen when this warm air near the earth rises?

Charles—It would reach a cold place in the sky and the water would form a cloud.

Teacher—Exactly. That is just how clouds are formed. The warm air near the earth picks up a lot of water vapor and carries it to colder places. This moving around of air at different temperatures is the cause of winds.[3]

Mary—Why the weather is influenced a lot by the temperature of the earth, isn't it?

Teacher—Can anyone tell me why we get snow in the winter?

Dora—It is so cold that frost is made in the clouds.

Teacher—Look at these pictures of snow crystals I have here and see how beautiful they are.

We might talk a long time about the weather, as it is a very interesting subject, but we have no more time now. Perhaps some time we will discuss how the weather man can tell what the weather is going to be.

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3 At this point a discussion on the "drawing power" of the sun,—the transfer of water from low lands to high lands,—water power, etc., could be brought in.

Experiments in General Science

E. J. Brown, Davenport, Iowa.

General Science lends itself to long and varied lists of experiments. A course may be made up entirely of experiments so entertaining and sensational that the real values which may be derived from general science are lost entirely.

The average pupil in our Junior High School has too much of the sensational injected into his life. Merely entertaining him, instead of leading him to solve every-day sicentific problems, is falling far short of obtaining any objective.

Experiments in general science have a very important place if rightly conducted. As an illustration, let us take a project on fire prevention. It is well to show the pupil the dangers of gasoline explosions, gas explosions, dust explosions, and the principle of the carbon dioxide fire extinguishers, but the project should not be merely set up as a source of entertainment. The pupil should have a vital part in solving the problems involved.

An experiment is justified only if it helps the pupil to grasp the idea. Every experiment should lead to the solution of a problem. If the idea can be put across without the experiment it is time and energy wasted to conduct it.

Then, too, an experiment should not be followed by lengthy descriptions and drawings of the apparatus. For many pupils the general science offered in the Junior High School makes up the sum total of their scientific knowledge. If we, as general science teachers, are awake to our opportunities, we have little time for details and technical diversions.

There are few subjects offered in the Junior High School age that can be made to function more completely than general science if properly directed. The thing we need to set up is a point of view. Every lesson should be seized as an opportunity of opening up the great field of science to the pupil and guiding him in interpreting his environment intelligently. Thereby leading him to become an intelligent citizen, able to function more completely in the complex civilization of which he will become a part tomorrow.

Tetra-Ethyl Lead Used in "Ethyl Gasoline"

The new anti-knock chemical—Tetra-ethyl lead—which is added to gasoline, has brought recent publicity to itself through the poison victims at the Standard Oil Plant at Bayway, New Jersey, lead poisoning resulting in acute mania having been produced in a number of workers. Professor Henderson of Yale University declares in "Science Service" that:

"There is nothing at all mysterious about this insanity gas of Bayway. Among metals of high toxicity lead ranks only a little below arsenic and mercury. It is the most highly cumulative poison known. Individual susceptibility to lead varies more widely than to any other poison. Some persons are affected by slight exposure, others are relatively resistant to large doses. Lead poisoning manifests itself in more different forms than any other intoxication. When contained in food or water it is readily absorbed and in some forms it appears also to be absorbed through the intact skin.

"The total amount that need be absorbed through any channel in susceptible persons is very small in order finally to induce a toxic effect. This effect may appear suddenly without previous warning and then be acute. A single milligram of lead per day for some months may induce illness. Slightly larger amounts for a shorter time have a similar effect. The commonest symptoms are intense abdominal pain, called "painter's colic," muscular paralysis, particularly wrist drop, loosening and loss of teeth, emaciation and abortion in women. Young women are peculiarly susceptible to lead poisoning. Many other constitutional disturbances are also charged to lead.

"The inhalation of volatile substances containing heavy metals always causes far more acute poisoning than does the swallowing of a merely soluble form such as a salt of that metal. This statement does not refer to dusts but to gases truly absorbed through the lungs directly into the blood. The alimentary canal and liver which have the power to stop and hold metallic poisons are thus avoided and the action of the substance is exerted primarily upon the nervous system. The best known example of this distinction is the effect of inhaling arseniureted hydrogen in contrast to that

of swallowing the ordinary solid and soluble forms of arsenic. The soluble and volatile forms of mercury show a similar distinction in their behavior. Even metals which when swallowed are practically non-toxic are poisonous in volatile form.

"Tetraethyl lead is a liquid. Its vapor may be regarded as virtually volatile lead for the atomic weight of lead is 207 and the four ethyl radicals together weigh only 116. The substance is therefore two thirds lead.

"So far as I am aware no experiments on animals to determine the toxicity of tetraethyl lead have been made. But through various channels which I know to be reliable I have learned from time to time that at practically every stage of the development of tetraethyl lead acute poisonings have occurred, some in the common form and some in the maniacal form. As an expert in this field I should say no animal experiments are needed to prove toxicity, it is extremely unlikely also that any positive remedial treatment can be developed. This opinion is based on extensive experience as physiologist in chief of the war gas investigations, later the Chemical Warfare Service during the war, when I was responsible for a corps of investigators who made tests on animals and men regarding all poisonous gases. There is really nothing at all mysterious about this insanity gas of Bayway.

"The amount of tetraethyl lead added to gasoline is small yet if all cars used it a person on Fifth Avenue, New York, in eight hours would inhale about the minimum amount sometimes inducing symptoms of lead poisoning. I pointed this out to representatives of General Motors two years ago. They claim that most of the lead is accumulated in the muffler of a car and is not discharged. Obviously, however, when a cylinder misfires, as in cars in repair shops and garages, while warmin up, and even on streets, undecomposed tetraethyl lead may be discharged.

"It is reported that the method of dispensing tetraethyl lead to the public is to attach a small tank of the highly concentrated substance to the gasoline pumps at roadside filling stations. A small amount is added to each gallon of gasoline and it is pumped into the tank of a car. A warning accompanies each tank but the names reported as commonly used for the substance such as ethyl gas and ethyl alcohol are not indicative of an acute poison.

"Lead by preventing premature explosions increases efficiency. It makes possible engines using much higher compression than at present. The introduction of cars with such engines would put

all present automobiles out of date, so that the market could be resold. We should all want one of the new ones.

"I have been trying for many months past to warn the health authorities and the general public of this new hazard. When the outbreak of poisoning at Bayway was reported in the newspapers and when the officials of the company adopted a policy of secrecy I stated that the mysterious insanity gas was tetraethyl lead."

Bureau of Mines Tests "Ethyl Gasoline"

Government experts at the U. S. Bureau of Mines at Pittsburgh, declare that the industrial hazard of manufacturing of tetraethyl lead and the hazard of use in automobiles are very different, from the fact that in the manufacture the concentration is high, but in the automobile exhaust gases, it is low. We are told in "Science Service" of their tests as follows:

To test the possible hazard due to the exhaust gases from automobiles using ethyl gasoline as ordinarily sold, pigeons, guinea pigs, rabbits, dogs, and monkeys, over 100 animals in all, were exposed to a definite concentration of exhaust gas from an engine using ethyl gasoline. The concentration of exhaust gas in air used was that which, when coming from the average automobile would be four parts carbon monoxide in ten thousand parts of air; a concentration allowable for but a period of one hour exposure from the standpoint of carbon monoxide, and exceeding that known to exist in ordinary traffic of a city street.

Two groups of animals were exposed for daily periods of three and six hours, respectively, and the third group not exposed. The animals were observed throughout the test period of eight months for symptoms of lead poisoning, as colic, paralysis, loss of appetite and loss of weight, and there was no indication of lead poisoning. At various times animals were killed and the entire tissues examined for effects of lead and analyzed for stored-up lead.

Observations made on man showed that most of the lead in exhaust gases coming from ethyl gasoline when inhaled is again exhaled. The investigation indicated the seeming remoteness of any danger of undue lead accumulation in the streets through the discharging of scale from automobile motors.

Carbon Monoxide More Deadly than Tetraethyl Lead.

Increase in the consumption of tetraethyl lead gasoline for automobiles is not a health danger of terrifying proportions, ac-

cording to Dr. Warren K. Lewis, head of the department of chemical engineering at the Massachusetts Institute of Technology. He says the use of ethyl gas, by decreasing the carbon monoxide content of exhaust gases from automotive engines, would prove beneficial rather than harmful to pedestrians on crowded thoroughfares.

"The danger in the distribution of tetraethyl gas is non-existent," he declared. "The extensive use of this lead compound in gasoline would not lead to a chronic lead poisoning as some authorities have predicted. Insanity and tuberculosis would not increase, and if anything the general health of the population as a whole should be bettered.

"When ethyl gas is burnt in automobile engines, very fine particles of lead oxide are formed. Part of this substance remains in the cylinder of the engine, some is left in the muffler, but by far the greatest portion of it is disseminated through the air as very fine particles of lead dust," he said.

A person would have to be exposed to the exhaust gases of an engine burning ethyl gasoline for 27 hours before any sign of lead poisoning would be noticeable. Before this time would have expired, however, the carbon monoxide in the gases would have proved fatal.

"The carbon monoxide content of the exhaust gases is far more important than the lead," said Dr. Lewis.

"Carbon monoxide is in itself a dangerous and treacherous poison and in dense traffic, as at the present time on Fifth Avenue, New York, the carbon monoxide content of the air very nearly approaches the danger mark, but the danger is from the carbon monoxide rather than from the lead."

Dr. Lewis's attention was called to the assertions that tetraethyl gas could not be distributed at a gasoline station without casualties. He said this was preposterous.

In brief, Dr. Lewis explains the advantages of tetraethyl gas to automobile owners as follows: "The addition of small amounts of tetraethyl lead to gasoline permits of greater compression of the gasoline vapors before they are exploded and should therefore ultimately lead to the production of more efficient gasoline engines. In gasoline engines which are now in common use it prevents knocking and produces a smooth, powerful stroke, not unlike that of steam. It makes possible running an engine on a leaner

mixture of gas, so that the mileage per gallon of fuel should be materially increased."

The research laboratories of all the larger petroleum products companies have been seeking for a number of years some compound such as tetraethyl lead which would insure more complete combustion of the gasoline and lead to increased economy in the operation of gasoline engines.

At the outbreak of the war the General Motors Research Corporation at Dayton, O., found that aniline had such properties. It was also found that the ethyl compound of selenium would effect a similar economy. It never came into extensive use because of its very offensive odor.

The Working of the Automobile*

TO STOP an automobile or a truck, we have to apply the brakes for a greater distance, if the vehicle is moving rapidly, than we do if it is moving slowly. This is a matter of every-day experience, and the fact is well known to all drivers. A good many of them, however, appear to have an idea that the difficulty of stopping the car increases *simply in proportion to the speed*—whereas the fact is, that it increases (other things being equal) in proportion to the *square* of the speed. This is a totally different thing, and the difference ought to be thoroughly understood, because lives often depend upon it.

We throw on the brakes, and they stop the car within a certain distance; but drivers have only a hazy idea, as a rule, as to what this distance is, to which the care must of necessity go, in spite of brakes, before stopping. The present articles discusses this question, and to tell the story rightly we must first say a few words about "energy."

MECHANICAL ENERGY AND HEAT ENERGY.

A moving car or truck, like every other moving object, possesses a certain amount of "energy" on account of its motion. We cannot see energy nor feel it nor weigh it; yet it is a real thing, and it cannot be either created or destroyed. It can be changed from one form into another, but that is all.

When an automobile is moving forward on a smooth, level road, and we throw out the clutch without setting up the brakes, the

*Printed by courtesy of "Travelers Standard," Travelers Insurance Co., Hartford.

car continues to roll along for a considerable distance. If we tied a rope to the rear axle and carried the rope over a pulley and fixed things so that the forward motion of the car would make the rope lift a heavy weight, the car would stop much sooner than it would if left to itself, because you can't raise a weight without doing work. In other words, you have to expend *energy* upon it, and in the case we are considering this energy is given up by the car, and its loss causes the car to slow down. The energy that is thus taken away from the car is not destroyed, however. It is only stored up in the weight, and we can get it back by letting the weight descend in such a way that it does work upon machinery of some kind or other as it comes down. Of course the amount of energy stored by raising the weight will be less (on account of friction) than the amount that is taken away from the car, but the friction does not *destroy* any part of the energy. It merely changes it into *heat,* which is another form of energy. And when the car is allowed to run along a smooth, level road until it comes to a stop without using the brakes, its energy of motion is not destroyed. It is merely frittered away in the form of frictional heat, and in the stirring up of air currents. If we could collect all these odds and ends of dissipated energy after the car has stopped, we should find that they would be precisely equal, in the aggregate, to the energy of motion that the car had when it was moving. This is not an assumption, nor is it a mere approximation. It is an exact statement. It would be a long story to tell how we know this, but the fact was discovered and proved many years ago, and the proof will always be regarded as one of the greatest triumphs of the nineteenth century.

THE BRAKE AS A TRANSFORMER OF ENERGY.

Now applying this principle to the automobile, we note, first of all, that it means that when the car is traveling forward at a good rate of speed we cannot possibly stop it with absolute suddenness. It must move forward or sidewise, or must turn somersaults or roll over, or keep going in some other way, until the energy of motion that it possessed has *somehow* been changed into heat. That is where the brake becomes serviceable, because a brake is merely a device for transforming the mechanical energy of the car into heat, more quickly than it would be transformed by the natural friction of the moving parts of the car, aided by that of the tires upon the road surface; and for every 780 foot-pounds of mechani-

cal energy that we take away from the car, we may be sure that one British thermal unit of heat will show up, somewhere or other—mainly at the brakes, if they are in good order.*

If we apply the brakes hard enough to lock the wheels, the tires will slide on the ground; but if we apply them less strongly than this, the wheels will continue to roll and the brake drums will rub against the brake linings. In either event heat will be generated at the point where the friction occurs—on the ground or at the brake-drums—and the energy of motion of the car will disappear at the rate of 780 foot-pounds for every unit of heat that is thus developed.

The action that takes place in stopping a car is the reverse of what occurs in a heat-engine. The heat-engine transforms heat energy into mechanical energy, thereby causing a certain amount of heat to disappear and an exactly equivalent amount of mechanical energy to be developed; while in applying the automobile brake we perform the opposite transformation, causing a certain amount of mechanical energy to disappear and an exactly equivalent amount of heat to be developed at the same time.

Dr. Julius Robert Mayer, in a paper that he published away back in 1842—the first paper, in fact, that was ever written on the mechanical equivalent of heat—stated the brake-situation quite clearly, except that inasmuch as the automobile had not then been invented, his remarks were confined to railway trains. "Our locomotives," he said, "may be compared to distilling apparatus; the heat beneath the boiler passes into the motion of the train, and is again deposited, as heat, in the axles and wheels," and of course in the brakes, when those are applied. This comparison is a good one, and drivers should bear it in mind. We recently heard a man assert that he can stop his car within eighteen feet, when traveling at sixty miles an hour; and he believed it, too, because he did not understand what the brake really does.

Ordinarily, the amount of heat that is set free at the brake in this way, in consequence of the disappearance of the mechanical energy of the car, is only enough to make the brake warm, or perhaps moderately hot; but when the vehicle has been going down a long hill or a long series of short hills, one after another, we have to use up the energy that corresponds to the descent of

*A "British thermal unit" is the quantity of heat that is required to raise the temperature of one pound (i. e. about one pint) of water by one degree Fahrenheit.

the car from the higher level to the lower one; and the heat generated must therefore correspond to the speed that the car *might* have developed in consequence of this descent, as well as to the speed that it actually *did* have. Under such circumstances it often happens that the heat set free is so great that the oily and greasy material on and around the brake drum takes fire, and sometimes the fire even spreads to the car itself and destroys it. Thoughtful drivers, partly to avoid trouble of this kind and partly to make sure that the car does not get out of control, often shift into second or first gear in going down long or steep hills. "Going into gear" in this way does not lessen the amount of heat developed, but it distributes the heat among the various working parts of the car, instead of allowing it to be concentrated at the brake drums.

HOW MUCH MECHANICAL ENERGY DOES A MOVING CAR POSSESS?

To make the thing a little more definite, suppose we figure out just *how much* heat the brakes of a given automobile must set free, before the care can stop. To find out how much energy of motion there is in a body that is traveling forward at a certain speed, we multiply the speed (as expressed in miles per hour) by itself, and then we multiply the product by the weight of the body (in pounds), and divide by 30. The result is the number of foot-pounds of mechanical energy that the body possesses in consequence of its motion. Suppose, for example, that an automobile weighs 2400 pounds and is moving with a speed of 25 miles an hour. We proceed as follows:

The square of the speed is $25 \times 25 = 625$, and multiplying this by the weight of the car in pounds, we have $625 \times 2400 = 1{,}500{,}000$; and this divided by 30 gives 50,000. In other words, the car possesses 50,000 foot-pounds of mechanical energy, just because it is moving at 25 miles an hour; and it will be impossible to stop it without changing these 50,000 foot-pounds of mechanical energy into heat.

Dividing this number of foot-pounds by 780 we have

$$50{,}000 \div 780 = 64,$$

which means that in stopping the car there will be 64 British thermal units of heat developed—that is, enough heat to raise the temperature of one pound of water by 64 Fahrenheit degrees—or (say) to raise the temperature of one quart of water from 70° Fahr. to 102° Fahr. This assumes that the car is traveling on a smooth, level road, and that the engine is thrown out of gear, so

that the heat developed at the brakes is due solely to the momentum (or more properly, the "kinetic energy") that the car has, on account of having a speed of 25 miles per hour when the brakes are set up.

If the car (together with its load) weighs 2400 pounds as before, and if it runs down a hill 200 feet high (as measured vertically), with the brakes applied just hard enough to keep the speed constant, then the amount of heat that must appear at the brakes on account of the loss of elevation of the car (and the consequent disappearance of "potential energy") would be

$$2400 \times 200 = 480{,}000$$

if expressed in foot-pounds, or

$$480{,}000 \div 780 = 615$$

if expressed in British thermal units. In other words, enough heat would be set free at the brakes, on account of descending the hill, to raise the temperature of 615 pounds of water by 1 Fahrenheit degree. This is a little more than enough to raise half a gallon of water from 70° Fahr. up to the boiling point.

HOW FAR MUST THE CAR RUN BEFORE THE BRAKES CAN STOP IT?

Having now discussed the general principle on which the brake acts, we proceed to consider the *efficiency* of the brake, as judged by the distance to which the care must travel, after the engine has been thrown out of gear and the brakes have been strongly applied with the car moving at a given rate of speed. This is partly a theoretical question and partly a practical one. The rule given above for finding the total energy of motion of the car, in foot-pounds, shows that this energy varies with the *square* of the speed of the car, being fourfold as great when the speed is doubled, ninefold as great when it is tripled, and so on. On the other hand, the generation of heat when the brakes are applied with a given constant force is proportional simply to the amount of slip between the brake-lining and the drum—or, in other words, to the distance the car travels before coming to a stop. Taken together, these two statements mean that if the brakes are applied with a certain standard force, then the distance that the car will travel before coming o rest is proportional to the *square* of the speed that it had when the engine was shut off and the brake was applied. This assumes that the car is traveling over smooth, hard, level ground, and that the stopping action is due to the brakes alone. In reality there would be some additional friction between the

moving parts of the car itself, and also between the tires and the road surface; but for practical purposes it is not important to consider these secondary sources of riction, because we are assuming (1) that the tires *rioll* on the ground, and (2) that the car is in good condition, so that its internal friction is small when the engine is out of gear.

Experiments have shown that the law of brake-friction thus indicated by theory is well borne out in practice. A short time ago we gave a rule, in THE TRAVELERS STANDARD, for determining the shortest distance within which a moving car can be stopped, if the brakes are in good condition—the constant entering into it being based upon actual tests. We will repeat that rule here, except that we shall now use a slightly different value of the constant, to bring the rule into conformity with the present practice of the New York City authorities, who are paying so much attention to the brake question. The rule as thus modified is as follows:

RULE: Multiply the speed of the car, in miles per hour, by itself, and divide the product by **11**. The result is the number of feet that it is reasonable to suppose the car will travel before coming to rest, if the brakes are in good order, and are thrown on as hard as they can be, without locking the wheels.

This rule assumes that the car is provided with brakes on only two wheels, and it also assumes that the car is of average weight and not loaded very heavily, and that the roadway is smooth, hard, and level. The rule is not given with the idea of allowing the owner of the car to prophesy with precision, but for the purpose of enabling him to judge whether or not his brakes are properly effective. We also hope that it will bring home to him the fact that when he is moving at high speed he *cannot* stop his car until it has traveled to a considerable distance—a distance much greater, in fact, than most car owners would believe to be necessary. The distances that the car *must* travel before it can be stopped are given, for various speeds, in the accompanying table, and also in the full-page illustration. These should be carefully studied by all drivers of automobiles and trucks.

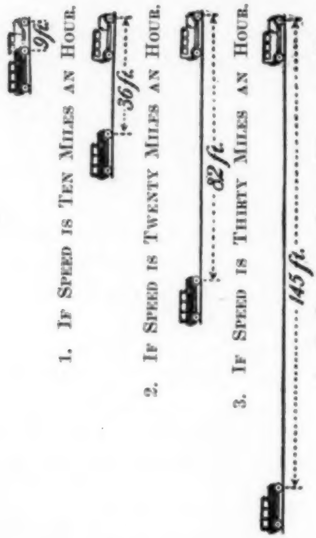
In practice, the distance that a car must run before it can be brought to a standstill will depend upon a number o fthings besides the speed and the condition of the brakes. It will depend quite largely, for example, upon the condition of the road surface, and also upon the weight of the car *and its load.* If a truck or car

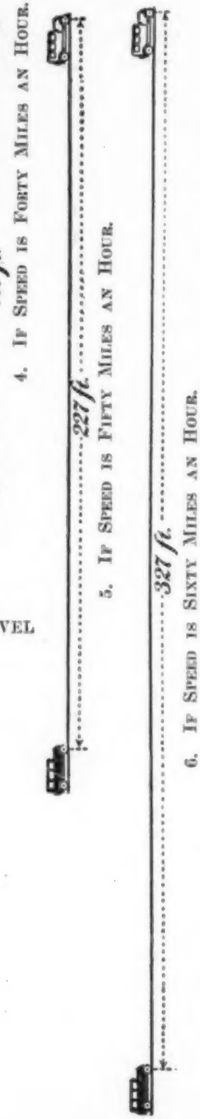
is heavily loaded, then of course the load is moving with the same speed as the car, and hence it contributes to the energy of motion of the vehicle as a whole; and this means that it is harder to stop a car that is loaded than it is to stop the same car when it is empty. This simple and rather evident fact is often overlooked by drivers, and we have frequently known it to be called in question by persons expressing views on the brake problem. It does not make any difference whether the moving matter that is to be stopped is present in the form of a solidly-placed load that will not fall off when the brake is applied, or in the form of extra steelwork or woodwork, forming part of the car itself. We certainly cannot stop the car and its load until we have converted *all* of the energy of motion, whether it resides in the car or in the load, into the form of heat at the brakes. The rule, table, and illustration are supposed to represent ordinary *average practice,* and good, level, non-slippery road surfaces.

The experiments upon which the foregoing rule is based were made before the advent of the four-wheel brake, and they relate simply to the stopping action of the ordinary two-wheel brakes that are provided on most of the cars that we meet on the highways. We cannot here discuss the four-wheel brake idea, but we may say that whether there are two brakes or four on a car, the distance that the car wil ltravel after the brakes are fully applied will vary with the square of the initial speed in either case; but the constant that occurs in the rule will be different when four-wheel brakes are used. Experiments to determine this constant for four-brake cars have been made in England, but we have not yet seen the results.

THE NEW YORK "BRAKE SQUAD."

At the present time New York City is maintaining special traffic officers (popularly known as the "Brake Squad") for the purpose of testing the brakes of automobiles that are using the city highways. Two of these officers will stop a car, and one of them will ride along in it while the other takes the necessary observations from the street. The car is brought up to a speed of 10 miles per hour, and then at a given signal the engine is cut out and the brakes applied, and the distance that the car travels before coming to a stop is noted. The experiment is repeated with the car going at 20 miles an hour, and again with it going at 30 miles an hour. Each experiment, moreover, is performed with the





SHOWING THE DISTANCE THAT THE CAR MUST TRAVEL, AFTER THE BRAKES ARE APPLIED.

(It may go much *further* than here indicated, but it cannot be stopped *sooner*. The diagrams are drawn to scale.)

TABLE OF DISTANCES.

SPEED OF CAR, IN MILES PER HOUR	DISTANCE, IN FEET, THAT THE CAR MUST TRAVEL BEFORE STOPPING
5	2
10	9
15	20
20	36
25	57
30	82
35	111
40	145
45	184
50	227
55	275
60	327

service brake and the emergency brake, separately. If the car can be stopped, whichever brake is used, within the distances calculated by the foregoing rule for these speeds, it receives a certificate of good character so far as the brakes are concerned, and the driver is allowed to go. If neither brake comes up to the standard, the owner of the car is fined for using the highway with his brakes in an unsafe condition. If one set of brakes meets the requirements and the other does not, the number of the car is taken and the driver is instructed to have the inefficient brake made right, and to report again for a second test at a stated time—failing in which, the owner of the car is also fined.

During 1923, 73,633 motor vehicles were inspected on the streets of New York in this way, and of this number 10,517 had one defective brake each, and the drivers were required to report back for reinspection with the defective brake fixed. In 2,239 cases both brakes were defective and the drivers were fined—the usual pnalty being $25.

SUMMARY.

The illustrations given in connection with the present article will give a very good idea of the behavior of a car that is moving at a given speed when the engine is disconnected and the brakes fully applied. Diagrams of this general sort have been published elsewhere in the past, but we have never seen one which was *drawn to scale,* and if they are not drawn to scale they are likely to be quite misleading, even though the correct figures are given under them.

The general lessons to be learned from this present article are three in number: (1) Keep your brakes, both service and emergency, in such condition that you can bring your car to a full stop within the distance that the rule indicates for the speed at which you are traveling; (2) do not forget that when you are moving at a high rate of speed, you cannot possibly stop your car until it has gone much further than you are likely to realize; and (3) remember that it is harder to stop a heavily loaded car or truck than it is to stop the same car or truck when it is loaded lightly.

"Be Wise With Speed"

THE words used for the title of this article were written many years ago by Edward Young, and referred to the importance of acquiring common-sense and sound judgment at an early age, as is indicated by the remainder of the sentence, "A fool at forty is a fool indeed." Young's advice is as good at the present time as it ever was, but in addition we may perhaps be allowed to read an entirely different and modern meaning into the phrase "Be wise with speed," so that it will serve as a good text in connection with present-day means for rapid transportation, by automobile and by motor-truck. Let us interpret it to mean, also, "Be wise in the use of speed."

A recent estimate of the number of automobiles in the United States places the total at 15,280,000, including both passenger vehicles and motor-trucks. Almost any owner of one of these conveyances would feel offended if it were suggested that the maximum speed of his vehicle is twenty miles per hour. The fact is, that with the exception of some of the heavier trucks, a far higher speed is well within the capacity of almost any motor-vehicle that is propelled by gasoline or steam. Yet even if the maximum attainable limit of speed of all self-propelled vehicles operated on the public highways were only twenty miles per hour, this would still be an immense increase over the speed of the horse-drawn vehicles that were formerly in general use for both pleasure and business, and this fact has an important bearing on highway and traffic accidents.

So far as we know, no complete and accurate records of highway and traffic accidents were kept, before the advent of the automobile. There are plenty of statistics concerning automobile accidents, however, and it is safe to say that if it were possible to compare the accident records for horse-drawn vehicles with those for automobiles, the number of those in the first-named class would be relatively insignificant.

The problem of preventing automobile accidents has become one of national importance, and no satisfactory solution of it has yet been found. This is largely because of the astonishing increase in the number of automobiles used. In 1895 only three hundred automobiles were registered in the entire United States;

by 1902 the number had increased to nearly 29,000 and it was realized that motor cars were soon to become an important factor in highway transportation. In 1922 more than 12,000,000 cars were registered; and it is estimated, as previously stated, that the number now in use exceeds 15,000,000.

Although, fortunately, the number of accidents has increased less rapidly than the number of automobiles put into use, the yearly totals have shown a large gain. For example, there were approximately 200 fatal automobile accidents in 1906, and in 1914 there were about 4,000. From 1914 to 1917 there was an increase in the yearly figures of about 5,000, and since that time the annual gain has been about 1,000 deaths, with a total for 1923 of approximately 15,000 fatalities. In addition, about 1,700,000 persons were more or less seriously injured in automobile accidents in 1923. Surely, these figures shows the appropriateness of the admonition "Be wise with speed" in the newer sense, and the importance of heeding it.

It should not be assumed, however, that automobile accidents would be entirely eliminated or even be reduced to a negligible number if the speed of motor cars were restricted to the rate of travel of horse-drawn vehicles, because excessive speed is but one of the many causes of accidents. This fact is doubtless recognized by those who are authorized to fix the legal rate of speed in the several states, and in our municipalities. There is a marked variation in the allowable speed in different parts of the country, however, and it may be that this is the result of attempts to prescribe a rate of speed that will be safe *under all conditions.* The result of fixing too low a speed limit is likely to be a universal disregard for the law with reference to it; but if the limit is too high, encouragement is given to the reckless drivers who constantly endanger the lives of all other persons on the highways. It seems to us that the best plan is to prescribe a generous maximum speed for travel on the open hghways, and a somewhat slower maximum speed for travel in thickly settled communities. This plan is in fact favored in many localities. It should be made plain, however, that these maximum speeds may not be permissible under all conditions and that persons may be penalized in case of accident, or if they are endangering other users of the highway, even if they are not exceeding the speed limit thus fixed. In other words, the motorist should be liable to arrest and punishment if he travels at a higher rate of speed than is reasonable when taking into con-

sideration the density of the traffic, the condition of the road-surface, the width of the thoroughfare, and various other special conditions, temporary or permanent, which affect the safety of all users of the highway. Under certain circumstances a speed of ten miles per hour may be excessive, while with other conditions it may be reasonably safe to travel at thirty miles per hour.

The proximity of curves, steep hills, underpasses, narrow bridges, blind street intersections, and other dangerous places are usually plainly indicated by warning signs, in states in which automobile traffic is heavy. The wise driver heeds these warnings and reduces the speed of his car accordingly. A large number of accidents occur on broad, straight, level stretches of road, however, and it is here that the admonition, "Be wise with speed," becomes of special significance, because drivers are likely to relax their vigilance somewhat when conditions appear to be favorable and safe. A considerable number of the accidents that occur on straight, level roads are the result of recklessness or bad judgment on the part of automobile operators when passing other vehicles. The more congested the traffic and the higher the speed of the moving vehicles, the greater is the chance for accident and the need for caution. The safe driver will wait for a favorable opportunity to pass the car ahead, and will then give adequate warning by sounding his horn. He will choose a place where the road can be seen for a considerable distance ahead, and will be sure that no cars approaching from the opposite direction are dangerously near, and that the road is sufficiently wide so that neither his own car nor the one he is passing will be forced off the highway.

It is going to take a long time and a great deal of effort to make highway travel safe, and there are many things to be done in addition to enacting laws and exacting fines for breaking these laws. As long as automobiles are made capable of traveling at high speed, there will be certain classes of persons—the reckless, the criminal, and the intoxicated—who *will operate* them at high speed, regardless of the consequences to themselves or others. For this small minority existing laws and ordinances must be rigidly enforced, and the punishment must be adequate to the offence in every case. There are other persons who must be considered, and who may and often do cause trouble without any malicious intent, and without consciously being careless or reckless. This class includes inexperienced drivers who are just beginning to operate automobiles, persons who are physically unsound, and

those who are temperamentally unfit to assume the responsibility of handling automobiles having large reserves of speed and power. The inexperience of the beginner can be overcome only by practice in the actual operation of a car under the supervision of a skilled and cautious driver. In too many cases, however, the new driver is left to his own devices before he has acquired the instinctive knowledge that causes him to act quickly and correctly in an emergency. As a rule, the instruction and supervision of new drivers should be extended over a longer period than is now customary.

The examining and licensing of prospective automobile operators should be made universal in all the states. The examinations should be thorough (in many cases they are now merely perfunctory), and should be such as to preclude the possibility of issuing licenses not only to persons who because of physical impairment lack the ability to manipulate the various controlling devices of the car, but also to those with defective vision, those who are mentally incompetent, and those who are obviously afflicted with nervous disorders or other ailments which would make it unsafe for them to operate automobiles.

Even if it were possible to eliminate all undesirables from among the great body of automobile operators, the guiding principle, "Be wise with speed," should still be kept in mind by all the remainder.

Decalog of Health

N. T. McNEIL.

1. I shall keep my body clean and unabused, for cleanliness is next to godliness, and abuse is unmanly.

2. I shall sleep eight hours every night, for sleep is more essential than food, and is the chief nourisher in life's feast.

3. I shall keep my body vigorous, and elastic by regular physical exercise and long walks.

4. I shall not neglect my teeth, for a foul mouth is a breeding place for disease.

5. I shall not abuse my eyes, for they are the windows of the soul, and without them I could see neither family nor friends, nor the beauties of sky, forest or field.

6. I shall breathe deeply to aerate my lungs and purify my blood.

7. I shall eat wholesome and nutritious food.

8. I shall remember that a healthy skin and a clear eye are the best indication of health.

9. I shall keep my bowels open, to prevent the accumulation of poisonous waste matter.

10. I shall think health, because mental attitude is the most potent and effective factor in the attainment and retention of health.

General Science Club Officers

The *General Science Club of New England,* at their fall meeting, elected the following officers:

President, John V. Jewett, Brookline High School.

Vice President, Dennis C. Haley, Boston Teachers College.

Secretary, Raymond S. Tobey, Boston Trade School.

Treasurer, John R. Dunn, Charlestown High School.

Executive Committee, the above officers and Lillian J. McRae, Joseph R. Lunt, W. G. Whitman.

At a meeting held January 31, 1925, the following program was given:

Demonstration Experiments in Light, Mr. Haley.

Teaching Demonstration with Class of Eighth Grade Pupils, Miss Keyes.

The Modern Cartesian Diver, Mr. Whitman.

Methods of Growing Yeasts, Molds, and Bacteria, Miss McRae.

Methods of Growing Yeasts, Molds, and Bacteria, Miss MacRae.

The New Science Library Plan, Mr. Lunt.

Some Industrial Applications of General Science, Mr. Tobey.

Demonstration Experiments on Fire, Mr. Dunn.

The New Books

Modern Business Geography—Ellsworth Huntington and Sumner W. Cushing—352 pages—101 maps and 84 photographs—$2.00—World Book Company.

This new textbook for the seventh, eighth, or ninth school year presents geography from an economic standpoint, and the method used is peculiarly effective in reawakening the interest of pupils who have studied the continents twice and think they have already had enough geography.

The book is organized into four parts dealing respectively with primary production, transportation, manufacturing, and consumption. This economic basis of treatment avoids the usual stereotyped, tiresome discussions by products or regions; with each part a wholly new set of principles is introduced and thus a fresh point of view is given.

An unusually large number of stimulating problems, questions, and exercises has been included to give the pupil practice in using the geographical facts which he has learned to think out problems for himself. The United States is treated extensively in the problems of every chapter as well as in special chapters. The rest of the world is treated more briefly, but each continent receives a special exercise and by this means the pupils review the geography of the whole world in a way new to them.

Exploring Nature—Charles H. Ward, Editor—257 pages—Henry Holt & Co.

This is a handy pocket-sized volume containing a collection of readings on science by some of our science masters. It is one of a series of books for English readings. The articles are science classics, and as usable in science as in English classes. Among the authors are found: Huxley, Darwin, Ball, Fabre, Slosson, and Thomson. The essays are grouped under these headings: "What Science Is," "The Heavens and the Earth," "How Plants and Animals Live," "The Evolution of Plants and Animals," "The Science of Society," "The Invisible World." This is an exceptionally fine book for supplementary work in General Science classes.

Elements of Physics—F. W. Merchant and C. A. Chant—546 pages—631 illustrations—Henry Holt & Co.

This Physics text is modern: first, because phenomena are explained as far as possible by using the theory of electrons; and second, because the applications of physics to every-day life include the very recent practical uses of physical science. The text covers the topics of the high school course, but carries them far enough for beginning college students. A good list of questions and problems follows each chapter.

Junior High School Mathematics—3rd Course—Vossburgh, Gentleman, and Hassler—294 pages—141 figures—The Macmillan Company.

This Junior High text follows the recommendation of the National Committee on Mathematical Requirements so that it may be successfully used in any ninth grade. The book is one in general mathematics work, wherein you find arithmetic, algebra, and geometry, although the algebraic problems predominate. The use of the graph for showing facts and for solving problems is explained.

Fungi and Human Affairs—W. A. McCubbin—111 pages—48 illustrations—$1.00—World Book Company.

This intensely interesting book tells of the part played by the small forms of plant life in our everyday affairs. Their relation to plant diseases is of great importance to agriculturists. The diagram "Carbon Cycle" furnishes material for a whole period of class discussion and is of a type well adapted for general science presentation.

Junior Mathematics—Ernst R. Breslich—147 pages—183 illustrations—Macmillan Company.

Junior mathematics is a first course in general mathematics for secondary schools. The material has been successfully used in junior high schools. It represents a fusion of arithmetic, algebra and geometry. The algebra is not stressed, however, above actual needs. Graphic representations and uses of angular measurements are given special prominence.

Outlines of Economic Zoology—Albert M. Reese—318 pages—189 illustrations—P. Blakiston's Son and Company.

This book makes the economic aspects of zoology the main point of attack while habits and morphology are treated as of secondary importance. It offers a practical course which is especially useful to agricultural students. Scientific classification is followed, but popular treatment makes the book interesting to the general reader.

Seeing America. Book 1. *Farm and Field*—Walter P. Pitkin and Harold F. Hughes—312 pages—illustrated—The Macmillan Company.

This is a new type of elementary geography reader in which the authors have attempted to put into a story of elemental human interest, information about the production of raw materials, about the difficulties of providing the necessities of life, about the wonders of machinery, and about conservation of natural resources. The authors have succeeded remarkably well in covering all this material in a narrative which is intensely interesting to the pupil. This volume treats fishing, forestry, quarries, milk products, coal, tobacco, turpentine, sugar, salt, cattle, and iron.

Outlines of General Zoology—H. H. Newman—480 pages—179 illustrations—Macmillan Company.

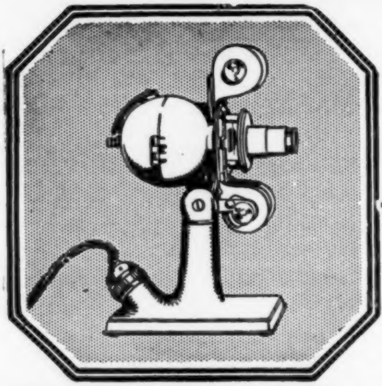
This is a college text based upon teaching practice. In general, the method is to begin with a historical survey; to follow this up with a general discussion of the problems associated with life, protoplasm and the cell; it then becomes necessary to present a series of animal types ranging from the amoeba to the frog, each type being used as a concrete illustration of one or more principles; finally a return is made to matters of general biology, the topics leading up logically to the principle of organic evolution.

Fifty Famous Farmers—Lester S. Ivins and A. E. Winship—407 pages—illustrated—Macmillan Company.

This is a valuable reading book for schools in a much neglected field. It tells with story-like interest of the life and works of those men who have advanced the world's greatest industry—agriculture. Scientific farming, upon which our own future depends, will undoubtedly draw many a new recruit from the boys who read this book and are inspired with the achievements of these fifty famous farmers. The men are grouped under farmer inventors, creators of better plants and animals, leaders in rural economic and social life, soil experts, administrators of agriculture, and secretaries of agriculture in cabinets of presidents.

Teaching Agriculture—James B. Berry—230 pages—23 illustrations—$2.00—World Book Company.

In this book the latest ideas of the teaching of agriculture are applied through the judicious use of proper pedagogical methods. The "acquiring of facts" is subordinated to "the intelligent use of facts in the solution of life's problems." The last chapter points out the duties, responsibilities and ideals of the teaching of agriculture. The appendix contains outlines for rural community survey and the Massachusetts life history folder.



Health for Every Day—Maurice A. Bigelow and Jean Broadhurst—235 pages—168 illustrations—Silver Burdett and Company.

This book on personal health opens with an important chapter on accidents and danger to health, and ends with one on self-control. The whole book emphasises the need of forming correct health habits. A unique feature of the book is the application of silent reading. To this end silent reading exercises are given under the heading, "Things to Ask, Answer, Tell or Do," which appear at the end of each chapter.

Health in Home and Neighborhood—Maurice A. Bigelow and Jean Broadhurst—328 pages—153 illustrations—Silver Burdett and Company.

This book summarizes the chief principles of personal health given in the companion volume, "Health for Every Day," and deals with health and sanitation in the home, school, and neighborhood. Physiology is treated only as required to an understanding of personal health in the home and surroundings. Manners, character, and mental and social welfare are included as belonging to a study of health. The book is planned for silent reading. Both books in this series have helpful suggestions to teachers.

Exercise and Review Book in Biology—J. G. Blaisdell—loose leaf—152 pages—illustrated—World Book Company.

This loose leaf manual is a time-saving device for laboratory work in biology. One hundred exercises are carefuly outlined and blank space for pupils' observations call attention to the important items to be recorded. Sketches are called for in many instances. Forty pages of review exercises and questions are found at the end of the volume. This should prove of great value to classes in the biology laboratory.

Laboratory Experiments in Practical Physics—N. Henry Black—157 pages—illustrated—The Macmillan Company.

This is a loose leaf manual of sixty-five experiments to cover Black and Davis' Practical Physics. The introduction to each exercise shows the relation of the exercise to other parts of the subject and defines the present problem. Tabulations are printed with blank forms in which the pupil records data of the experiment. This means a saving of much time for the pupil. Each exercise is followed by "Questions and Problems" which give meaning to the exercise as well as serving to review the work.

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ABRAMS

Our Abrams verdict. A. C. Lescarboura, Sci. Am., 131:158, Sept., 1924.

AERONAUTICS

Around the world by air. C. P. McDarment, Sci. Am., 131:230, Oct., 1924.

Round world in eight days next? Pop. Mec., 42:712, Nov., 1924.

AUTOMOBILE

When your motor car calls for help. E. B. Staples, Pop. Sci. Mo., 105:5:86, Nov., 1924.

CHARCOAL

Charcoal, the chemical truant officer. Ismar Ginsberg. Sci. Am., 131:328, Nov., 1924.

CITY PLANNING

New treatment of street intersections. Amer. City, 31:445, Nov., 1924.

COAST GUARD
Policing the seas for Uncle Sam. Pop. Mech., 42:579, Oct., 1924.

DE FOREST
The life and work of Lee De Forest. Ill. Radio News, 6:464, 658 and 912, Oct., Nov., and Dec., 1924.

EFFICIENCY
The human machine used to mutiply human energy. Alice Ravenhill, Nation's Health, 6:598, Sept., 1924.
The essentials of an efficient city engineering department. W. E. Weller, Amer. City, 31:321, Oct., 1924.

ELECTRICITY
Data for building electro-magnets. Ill. H. W. Secor. Experimenter, 4:40, Nov., 1924.

FARADAY
A famous experimenter. The Experimenter, 4:96, Dec., 1924.

FISHERIES
Battle to save salmon from extinction. Ill. Pop. Mech., 42:618, Oct., 1924.

GARDENS
All the year round in the California garden. A. M. Woodman. Gar. Mag., 40:243, Dec., 1924.
A personal view of California gardens. F. A. Waugh. Gar. Mag., 40:233, Dec., 1924.
Gardening in the mid-south. Ill. J. W. Manning. Gar. Mag., 40:187, Nov., 1924.
Southern shrubs or southern gardens. Ill. E. F. Rowe. Gar. Mag., 40:199, Nov., 1924.

HEALTH
Health work at Florida State College for Women. E. Conradi. Nat. Health, 6:661, Oct., 1924.
Changing the disease map. A. C. Abbott. Hygeia, 2:633, Oct., 1924.
Postural aids. Ill. Nat. Health, 6.620, Sept., 1924.
Exploiting the health interest: "Physical Culturists," Hygeia, 2:744, Dec., 1924.

HISTORICAL EXPERIMENTS
Frictional electrical machines. Experimenter, 4:14, Nov., 1924.
Faraday—a famous experimenter. Experimenter, 4:96, Dec., 1924.

HOUSEHOLD
Tools for the housewife. Ill. Anne Pierce. Hygeia, 2:673, Nov., 1924.
Important part domestic factors play in national health. Ill. Alice Ravenhill. Nat. Health, 6:667, Oct., 1924.

MAGNETISM
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NORWAY
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PAPER
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PEARLS
Jewelry from fish scales. Ill. D. K. Tressler. Sci. Amer., 131:180, Sept., 1924.

PLANTS
Exporing the mysteries of plant life. Ill. 16 pages in color. Wm. J. Showalter. Nat'l Geog. Mag., 45:581, June, 1924.

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Rebroadcasting the broadcasting program. W. J. Purcell. Sci. Amer., 131:164, Sept., 1924.
The four electro-vacuum tube. Ill. George Imlach. Radio News, 6:694, Nov., 1924.
What vacuum tube curves means. Ill. R. W. Hallow. Radio News, 6:698, Nov., 1924.
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Newtrodyne receivers. Ill. A. L. Groves. Radio News, 6:316, Sept., 1924.
Behavior radio waves and the heaviside layer. Sir Oliver Lodge. Radio News, 6:898, Dec., 1924.
Radio fire hazards at receiving stations. A. C. Huston. Amer. City ,31:357, Oct., 1924.

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WATER POWER
Over the mountains with white coal. H. E. Byram. Pop. Mech., 42:960, Dec., 1924.

WATER SUPPLY
Water of Providence, R. I. J. W. Bugbee. Amer. City, 31:425, Nov., 1924.
Protection of small water supplies. Ill. O. E. Brownell. Amer. City, 31:461, Nov., 1924.

WEATHER
Who says the weather man is always wrong? N. C. McLoud. Pop. Sci. Mon., 105:5:52, Nov., 1924.

X-RAYS
Testing Metals with X-Rays. Ill. Franz Fuchs. Prac. Elec., 3:640 and 698, Sept. and Oct., 1924.

Magazine List

American City. 443 Fourth Ave., N. Y. C. Monthly. $4.00 a year, 50c a copy. The science problems of city and rural communities are treated in numerous articles, well illustrated. A valuable student and teacher reference.

The American Food Journal. 25 E. 26th St., New York City. Monthly. $3.00 a year, 25c a copy. Articles on food manufacture, food legislation, and experiments in nutrition.

Commercial America. Phila. Com'l Museum, Phila., Pa. $2.00 a year. Ill. Commercial production. New inventions. Will interest commercial geography and science teachers.

The Educational Screen. 5 South Wabash, Chicago, Ill. Monthly except July and August. 20c a copy, $1.50 a year. Now the only magazine in the field of visual education, having absorbed *Moving Picture Age* and *Visual Education* during the past two years. It covers the entire field of visual aids, including the motion picture, authoritatively. It is independent of any commercial connection whatever.

Garden Magazine. Garden City, N. Y. Monthly. 25c a copy, $3.00 a year. Ill. Helpful to amateur gardeners, teachers and pupils.

General Science Quarterly. Salem, Mass. Quarterly. 40c a copy, $1.50 a year. The only journal published devoted alone to science in the elementary and secondary schools. It tells what schools are doing in science, gives lesson plans, demonstrations, and an extensive bibliography of usable articles in current periodicals.

The Geographical Review. Broadway at 156th St., N. Y. Quarterly. $1.25 a copy, $5.00 a year. Devoted to scientific geography. Original maps and pictures. One department contains condensed items of topics of current interest.

The Guide to Nature. Sound Beach, Conn. Monthly. 15c a copy, $1.50 a year. Ill. Of interest to elementary pupils and teachers of nature study.

Hygeia. 535 No. Dearborn St., Chicago. Monthly. 25c a copy, $3.00 a year. Popular articles on individual and community health. A valuable supplement to classroom work in hygiene.

Industrial and Engineering Chemistry. Box 505, Washington, D. C. Monthly. 75c a copy, $7.50 a year. A technical journal which contains much material which teachers can use.

Journal of Chemical Education. Easton, Pa. Monthly. $2.00 a year. Promotes chemical education; primarily a journal for the chemistry teacher. Digests of activities of chemical associations.

Journal of the Franklin Institute. Philadelphia, Pa. Monthly. 50c a copy, $6.00 a year. Ill. A technical journal. Contains many articles of value to science teachers.

Journal of Home Economics. 1121 Cathedral St., Baltimore. Monthly. 25c a copy, $2.50 a year. For teachers.

The Literary Digest. 354 Fourth Ave., N. Y. Weekly. 10c a copy, $4.00 a year. Has a department "Science and Invention." Articles are mostly digests from other journals. They are popular in nature and suitable for high school pupils.

National Geographic Magazine. Washington, D. C. Monthly. 50c a copy, $3.50 a year. Best monthly journal for high grade pictures. Articles are of interest to general reader, pupils and teachers, as well as to geographers.

The Nation's Health. 22 E. Ontario St., Chicago, Ill. Monthly. $3.00 a year, 25c a copy. An illustrated magazine devoted to community, industrial and institutional health problems. Very helpful to the science and hygiene teacher.

Popular Mechanics Magazine. Chicago. Monthly. 25c a copy, $3.00 a year. Short science items and articles well illustrated. Appeals strongly to elementary pupils. Suggests many construction projects.

Popular Science Monthly. 255 W. 39th St., N. Y. C. Monthly. $2.50 a year, 25c a copy. A review in text and pictures of the news of science and invention, presented in a humanistic and inspirational way. Used as a supplement to text-books in many high schools. Valuable to science pupils and teachers.

The Science Classroom. Issued by "Popular Science Monthly," October to June. 25c a year. A valuable teacher's aid, giving lesson plans, experiments, and many reference suggestions for secondary science teachers.

The Experimenter. 53 Park Pl. New York City. Monthly. 25c a copy, $2.50 a year. This is especially suggestive to boys who are making things. There are numerous articles on electrical, radio and chemical topics.

Radio News. 53 Park Place, New York City. 25c a copy, $2.50 per year. Monthly. A practical periodical for all who are interested in radio. Gives radio progress, new hook-ups, and gives much help to one who may wish to construct his own set.

Safety Engineering. 80 Maiden Lane, New York. Monthly. $3.00 a year. 25c a copy. A journal devoted to conservation of life and property and contains much material helpful in science classes.

School Science and Mathematics. Chicago. Monthly. $2.50 a year. A teacher's journal. Includes many helpful suggestions.

Scientific American. Woolworth Building, N. Y. Monthly. 35c a copy, $4.00 a year. Has longer articles than the other popular science journals. Illustrated, and is particularly valuable to high school science pupils and teachers.

Science and Invention. 53 Park Place, N. Y. C. Monthly. 25c per copy, $2.50 a year. Ill. Popular articles on astronomy, physics, photography, radio-activity, medicine, and, in fact, science in general.

Scientific Monthly. Garrison, N. Y. 50c a copy, $5.00 a year. Articles as a rule are more along lines of pure science. Much of value to teachers. Articles can be read to advantage by many pupils.

Science News-Letter. Science Service, 1115 Connecticut Ave., Washington, D. C. Weekly. 10c a copy, $5.00 a year. Gives a valuable current summary of the progress of science, in a form usable in science classes.

Transactions of the Illuminating Engineering Society. 29 West 39th St., N. Y. Monthly. $1.00 a copy, $7.50 a year. Technical. Many articles contain material which can be used in high school classes.